Validation of a new Mobile and Openly Available Processing Speed Test.

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Statement of Sources

I declare that this report is my own original work and that contributions of others have been duly acknowledged.

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Erin M. Van Der Kley Date

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Abstract

There are barriers to current tests of processing speed: cost, access, and learning effects. We aimed to develop a brief mobile test of processed speed, that correlates strongly with other tests of processing speed, has minimal learning effects, and acceptable test retest reliability. The Mobile Open Processing Speed test (MOPS), was adapted from the traditional WAIS Symbol search task. Participants examine and respond to an array of 6 symbols determining if any match the pair of target symbols. Symbols are comprised of both inner and outer shapes to increase task difficulty. Two studies were conducted to validate the MOPS. A 7-day test-retest study comprising of the MOPS, WAIS SS and SDMT tests in 68 healthy adults (28 male, 20-63 years); and an acute alcohol dosing study to determine sensitivity to intoxication (BrAC 0.05 and 0.08) in 36 young adults (15 male, 18-34 years). The MOPS correlated strongly with the WAIS SS (r=-0.69) and SDMT (r=0.74). Acceptable test-retest reliability (r=.80) and significant moderate magnitude learning effects were identified (d=0.59, p<.001). The MOPS was more sensitive to acute alcohol intoxication than the other measures (g=-0.31, p=0.114). Continuing validation, reduction of learning effects, and creation of norms are future directions for the MOPS.

As time is finite, the ability to be efficient in what you do and how you understand your constantly changing environment is crucial. The faster your ability to process information from the world around you, the better your cognitive ability and interactions with the world (Kail & Salthouse, 1994; Miller, 1988; Wickens & Carswell, 2006). The efficiency and speed at which information is perceived and acted upon is conceptualised as information processing speed (Sweet, 2018). Information processing speed underlies, and is associated with, various cognitive processes such as working memory and intelligence (Fry & Hale, 1996; Fry & Hale, 2000; Lichtenberger & Kaufman, 2009; Sheppard & Vernon, 2008). Reaction and response times are key methods to measure the speed information is processed. Current tests used to measure processing speed such as the Wechsler Adult Intelligence Scale processing speed index subtests, and the Symbol Digit Modalities Test (SDMT) are well established regarding their reliability and validity (Benedict et al., 2017; Wechsler, 2008). However, concerns about their usability, cost, availability, and sensitivity, has inspired the creation of new forms of processing speed tests. The introduction of brief, openly available, mobile tests of processing speed aims to address some of these problems while still maintaining similarities with the original tasks.

Theories of Processing Speed

Information processing can be conceptualised as a process whereby information from the environment is transformed to a response in a series of stages (Miller, 1982; Wickens, & Carswell, 2006). There is debate as to whether the information flows continuously through the stages, or jumps from one stage to the next. (Cowan, 1988; Miller 1982; Wickens, & Carswell, 2006). The basic premise behind information processing is information is received from the senses, attended to, and acted upon. The speed at which this occurs impacts and underlies various cognitive functions (Kail & Salthouse, 1994). These processes are expanded upon through various theoretical models.

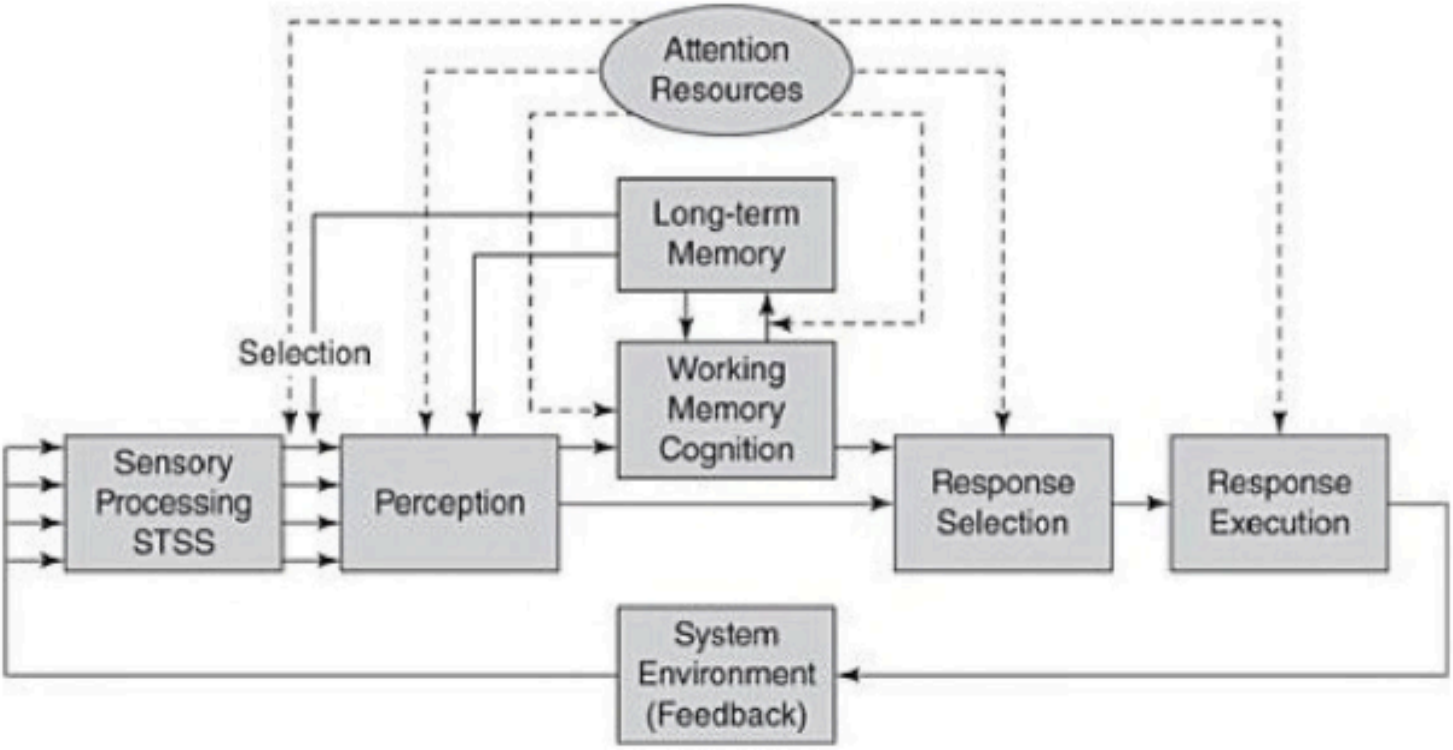
The Model Human Processor by Card, Moran, and Newell (1986), suggests three key systems work together to complete processing. These are: perceptual, cognitive, and motor systems, and each have memories and processors. Sensory information enters through the perceptual system, and is transformed into information for the cognitive system. Information in the cognitive system is modified in the working memory by long term memory content. Content in working memory influences the motor system, resulting in a response. The speed at which the information is transformed in memory and activates the motor system can be calculated to determine processing speed. Information from responses does not feedback into processing, instead information is passively received and responded to in this model without acknowledgment of the impact actions have on the environment (Cowan, 1988). The method of measuring speed of processing from the beginning of the working memory stage is complicated, and ignores the processing that occurs from the very first input of information.

Wickens' Information Processing model (Wickens, Hollands, Banbury, & Parasuraman, 2015) expands on the Model Human Processor model by providing a well rounded evaluation of 5 stages of information processing (As seen in Figure 1). In this model, processing speed is measured from the time stimuli is sensed to the time a response is recorded. The first stage in the model is awareness of sensory information in the environment. These sensations can be briefly held in a short term sensory store (Cowan, 1988). From sensation, the information needs to be given meaning. This comes from past experiences held in long term memory (LTM). Perceived information can travel through two different routes. Firstly, perception can trigger an immediate response, flowing directly through to the 4th and 5th stages of response selection and execution (See Figure 1). For example, the sensation of touching a stove that is perceived as hot results in the immediate response of pulling the hand away. This direct flow from perception to response execution often results in a quicker coordination and execution of cognitive functions and reaction time,

equating to a faster speed of processing. Yet, not all perceived information results in a rapid response. This is where processed information goes through the second route, through working memory and long term memory before response execution (Cowan, 2013; Wickens et al., 2015). Perceived information can be held in working memory while other information is gathered from long term memory to increase understanding. Information held in working memory can be manipulated and transformed to modify the response. Information does not always flow solely in one route or the other, it is argued that stages can happen in parallel (Townsend, 1990). For instance, rehearsing a phone number while writing it down demonstrates how two stages can occur in parallel. The perceived information (the phone number) passes through working memory; while writing it down bypasses working memory straight to response selection and execution (Wickens et al., 2015).

Finally, the last two stages include response selection and response execution. Acknowledging the execution of a response is key to identifying the speed information processing took to go from a sensation to a response. Feedback from the response is cycled back for evaluation by the sensory system to be processed again (Wickens & Carswell, 2006). The addition of feedback (called System Environment) in the Wickens' model is a point of difference from the Human Information Processor model. Processing speed is the speed at which information moves through these various stages from first sensation to response execution. The ability to measure processing speed through a variety of tasks, allows identification of if problems are occurring at the lower processing level, or higher order processes.

Figure 1: Diagram of the Wickens' Model of Information Processing.



Note: Stage 1: Sensory processing short term sensory store; Stage 2: Perception; Stage 3: Working memory cognition, Long term memory and attention resources; Stage 4: Response selection; Stage 5: Response Execution.
Reprinted from *Engineering Psychology and Human Performance* (4 ed, p 8), by Wickens, C. D., Hollands, J. G., Banbury, S., & Parasuraman, R. (2015). *Engineering Psychology and Human Performance* (4 ed.). New York: Taylor and Francis.

The Relationship Between Processing Speed and Memory

Working memory capacity and the speed encoding, transforming, and retrieving information within working memory occurs, is argued to be determined by processing speed (Fry & Hale, 2000; Conway, Cowan, Bunting, Therriault, & Minkoff, 2002). As working memory is limited in capacity, faster processing speed allows more information to be held, processed, responded to, and then ready for more information (Baddley, 1983; Barrouillet, Portrat, & Camos, 2011; Conway et al., 2002; Fry & Hale, 2000). If processing speed is slow the information will not be processed fast enough to be remembered and used.

Fry and Hale (1996) noted in their study of children and teenagers that after controlling for age differences, individual differences in processing speed were moderately and inversely correlated with working memory (r = -.546). The analysis also showed 71% of the total age-related effect on working memory was mediated by age related difference in processing speed. However, the measures of working memory Fry and Hale (1996) used in this study have been critiqued for measuring different constructs. Two of the measures used examined simple short-term memory through repeating back numbers; while the other two examined more complex working memory tasks. This creates an inability to determine whether processing speed is related to simple short-term memory or working memory in these results (Conway et al., 2002). Joy et al. (2004) noted that with the Digit Symbol Substitution Test of processing speed, working memory accounted for 15% of variance. While this may indicate a reciprocal relationship between processing speed and working memory; processing speed contributes a far greater amount to working memory than working memory does to processing speed (Diamond, 2014). As a result, tests of processing speed have demonstrated both weak and moderate correlations with tests of working memory (Conway et al., 2002; Sliwinski et al., 2018).

The Relationship Between Processing Speed and Age

The changes associated with aging, particularly that of slower processing speed, is a well established phenomenon (Fry & Hale, 2000; Robitaille et al., 2013; Salthouse, 1996). Common measures of processing speed, such as WAIS Symbol Search and Coding, Inspection Time Task (ITT) and Digit Symbol Substitution Test (DSST), are sensitive to deficits in performance as respondents age (Crowe et al., 1999; Ebaid et al., 2017; Robitaille et al., 2013; Salthouse, 1996).

Salthouse (1996) proposes that there are two mechanisms by which processing speed can limit higher order processes. These two mechanisms are the Limited Time Mechanism

and Simultaneity Mechanism. The Limited Time Mechanism states that the time available for later stages of information processing is determined by the amount of time spent processing earlier stages. When processing speed is slow, excess time is spent on earlier stages and the time available for later stages is restricted, resulting in functional problems. The Limited Time Mechanism can be understood through the continual processing needed to watch and understand a movie. If a person is still processing what has happened at the beginning of the movie while the next scene has started, there is not enough time to process this new scene before it moves on to the next. The effects of slowed processing speed on the Limited Time Mechanism are prominent when information processing is constrained to occur in a set time (Salthouse, 1996). Tests of processing speed often place time constraints on when processing needs to occur. In the WAIS Symbol Search respondents have 120 seconds to mark down their answers (Wechsler, 2008). A high number of total scores (correct minus incorrect) made in this time indicates processing speed is fast. Poor scores on tasks with time constraints (such as the WAIS Symbol Search) indicate the respondent may still be slowly processing earlier trials while time is counting down.

The Simultaneity Mechanism operates under the assumption that the availability of information decreases over time if it is not activated or processed quickly enough (Kail & Salthouse, 1994; Salthouse, 1996). This is prominent when a mental process (such as working memory) requires integration of a new piece of information to an older piece. If too much time is spent processing the new piece information, the first piece of older information no longer able to be accessed and consequently not available for integration. When deficits in higher order tasks contingent on processing information are detected, differentiating between if the cause lies with slow processing speed or with the higher order task itself is necessary. Tests used to determine processing speed are an easy way to identify if the cause is slow processing speed.

The Relationship Between Processing Speed and Alcohol

The effect of alcohol on the brain and the consequences this has for cognitive functions including processing speed is well documented (Jongen, Vuurman, Ramaekers, & Vermeeren, 2016; Moskowitz, & Fiorentino, 2000; Zoethout, Delgado, Ippel, Dahan & van Gerven, 2010) (see see Table 1). Alcohol acts as a central nervous system depressant (Zoethout, et al., 2010; Bjork & Gilman, 2014). Alcohol's effect on the nervous system and cognitive functioning is present even at low doses (Chui & Koob, 2017; Fillmore, Blackburn, & Harrison, 2008; Irwin, Iudakhina, Desbrow, & McCartney, 2017; Zoethout et al., 2010). Detecting impairment that occurs below the legal blood alcohol concentration limit is necessary for safety in tasks like driving (Cash et al., 2015). Driving requires many cognitive and motor functions work together (Irwin et al., 2017). Safety while driving is ensured when all processes are functioning efficiently and not impaired. However, consequences of alcohol's effects are not uniform across the domains of cognitive functioning (Jongen et al., 2016; Zoethout et al., 2010). As even low alcohol doses effect functioning, cognitive testing should be used to detect which cognitive functions are impaired (Fillmore, 2008; Moskowitz & Fiorentino, 2000; Irwin et al., 2017). Moreover, particular tests of processing speed vary in how sensitive they are to the effects of alcohol (see Table 1) (Fillmore, 2007; Moskowitz & Fiorentino, 2000). As processing speed underlies many tasks, knowing at which dose alcohol has a critical effect is important. The sensitivity of processing speed tests to detect impairment is central to ensure safety, even if a driver is below the legal limit (Conway et al., 2002; Friedman, Robinson & Yellend, 2011).

Tests of Processing Speed

When deficits occur in cognition and functioning the ability to identify the cause is crucial. The ability to measure processing speed allows causes of deficits to be identified; differentiating if the underlying cause is due to slowed processing or the problem is with the

higher order task itself (Conway et al., 2002; Haworth, Phillips, Newson, & Rogers 2016). Processing speed is expressed and measured through reaction and response times. These measures can either be the time in which a task or series of tasks were completed in, or the number of correct items/responses produced in a set amount of time (Sweet, 2018). The simple processing speed tasks follow the quicker route outlined in Wickens' Model. Where the stimulus is presented, sensed, perceived, and triggers a rapid response (Carlozzi et al, 2014). More complex measures of processing speed, such as the WAIS Symbol Search, often also involve some form of mental manipulation, decision making, or attention before responding. This follows the longer route in Wickens model, using the working memory and long-term memory processes (Carlozzi et al, 2014; Cepeda, Blackwell & Munakata, 2013).

Early developed tasks set up to measure the speed of processing were the Subtraction Task and Bourdon Task (Fillmore, 2007). The Bourden Task (also known as Dot Cancellation) was created in 1902. Participants were instructed to cross out all the dots on a piece of paper and the time to do this was recorded (Ono, Lillakas, Kapoor, & Wong, 2013). Adaptations of these tasks resulted in the creation of the Digit Symbol Substitution Task (DSST) and Letter Cancellation tasks that are widely used today (Fillmore, 2007). Processing speed has been assessed across the lifespan using paper and pencil tasks. In particular, the widely used Wechsler Adult Intelligence Scale added in a Processing Speed Index (PSI) into the third edition in 1997 (Wechsler, 2008; Ebaid et al., 2017), and is still currently used in the 4th edition. Within the Processing Speed Index (PSI) there are two subtests: the WAIS Symbol Search, and WAIS Coding. The WAIS Coding task is a renamed version of the Digit Symbol Substitution Task (DSST). The WIAS Symbol Search is a paper-and-pencil task, where participants need to search for one of two target symbols in an array of 5 other symbols. There is a total of 60 trials to complete in a maximum of 120 seconds (Lichtenberger & Kaufman, 2009). The DSST is a well-established test due to its ability to

discriminated between cognitive function and dysfunction (Jaeger, 2018; Lichtenberger & Kaufman, 2009). Both the WAIS SS and Coding have good test retest reliability (see Table 1). However, the overall WAIS PSI Index is influenced by practice effects. Participants scores improved on a second test session an average of 22 days after the first, increasing on average by 4.4 points from 100.2 to 104.6 (Lichtenberger & Kaufman, 2009; Wechsler, 2008).

There are also a variety of processing speed tests that are not part of the WAIS IV which are commonly used (see Table 1). The Symbol Digit Modalities Test (SDMT) is a simple substitution task, and uses a process inverse of the DSST. Users write the corresponding number to the symbol instead of drawing the symbol that matches the number (Crowe, Benedict, Enrico, Mancuso, Matthews, & Wallace, 1999). The SDMT test is advocated as an effective test to screen for processing speed and cognitive deficits (Benedict et al., 2017; Rao et al., 2017; Paramenter, Weinstock-Guttman, Garg, Munschauer & Benedict, 2007). Deficits in processing speed are characteristic in neurological diseases like multiple sclerosis (DeLuca, Chelune, Tulsky, Legenfelder, & Chiaravalloti, 2004; Demaree, DeLuca, Guadino, & Diamond, 1999). Tests of processing speed such as the The Paced Auditory Serial Addition Test (PASAT) are used to identify multiple sclerosis cognitive impairments as no demand is made on motor ability (Demaree et al., 1999; Tombaugh, 2006; Walker et al., 2012). Yet one study by O'Jile et al. (2006) found that learning effects in the PASAT resulted in no difference being identified in scores between people with head injuries and those without. The difference in sensitivity of the PASAT can be mediated by variety of factors, such as learning, attention demand, or fatigue effects. Lengthy tasks, such as the PASAT, Computerised Test of Information Processing, and Inspection Time Task (see Table 1), place high demands on respondents' attention and cognitive resources and impact results (Makdissi et al., 2001; O'Jile et al., 2006; Paramenter et al., 2007; Tombaugh, 2006). The

complicated nature and difficulty of the PASAT has resulted in both participants and administrators viewing it negatively (Rao, et al., 2017; Walker et al., 2012). Participants have been recorded feeling anxious, sad, and even hostile while completing the PASAT (Walker et al., 2012). These results affect performance and reduce participants' willingness to complete the test in follow up sessions (Tombaugh, 2006).

The current tests of processing speed are expensive, ranging from hundreds of dollars up to $2820 AUD for the WAIS tasks and additional $355AUD for the digital extension of the tasks to iPad (see Table 1) (Pearson, 2019). Many tasks require administration to be done by a trained psychologist or other professional, which reduces the availability of the tasks to be used in a variety of situations as needed (see Table 1) (Schatz & Zillmer, 2003).

Another major critique of current measures of processing speed is that there is difficulty obtaining a pure measure of processing speed (see Table 1) (Cepeda, Blackwell & Munkata, 2013; Conway, Kane, & Engle, 2003; Ebaid et al., 2017). Processes such as working memory, visual-motor coordination, visual discrimination, psychomotor speed, and motor dexterity all can be involved in a measure of processing speed (see Table 1) (Cepeda, et al., 2013; Crowe et al., 1999). Tasks such as the Inspection Time Task (ITT) and computerised SDMT, aim to reduce the effects of motor dexterity using verbal responses or digital tablets which do not require holding a pen. Yet these tasks are expensive and are not available as open source tasks (and the ITT requires the use of difficult to find cathode ray computer displays). Motor performance is also a major influencing factor confounding performance and contributes to variance on the pencil-and-paper tests such as the WAIS SS and Coding, DSST, and SDMT (see Table 1) (Ebaid, et al., 2017; Lichtenberger & Kaufman, 2009). Participants' reduced motor dexterity or speed hinders their ability to write, reducing their overall scores. The effect of motor speed has been shown to contribute significantly to DSST (semi partial correlation, *Sr,* = .087) SDMT (*Sr* =0.133) and WAIS SS (semi partial

correlation = 0.188) scores (Crowe et al., 1999). Age is commonly associated with reduced motor dexterity, yet, when motor dexterity is controlled for, significant differences on the paper-and-pencil measure across the age groups are still present indicating the presence of age-related processing speed deficits (Ebaid et al., 2009). It is difficult to differentiate whether the slowed responses are due to impaired motor responses, cognitive impairment or a combination of both (Carlozzi et al., 2014). To gain further insight into unhindered processing speed, the confounding influence of motor speed needs to be removed or reduced. This is one advantage of computerisation, especially tasks completed on mobile smartphone or tablet devices (Brouillette et al., 2013; Dufau et al., 2011). Motor confounds are reduced as no pencils or computer-mice are needed, participants only need to tap answers. A mobile SDMT has been created by Tiplady (2009) in a software package for Android tablets called Penscreen. The WAIS SS has not been currently computerised (McLeod, Griffiths, Bigelow, & Yingling, 1982).

The development of brief mobile tests of cognitive function are increasingly seen as good supplements to the current tests of processing speed (Cossavin & Elbin, 2010; Broglio, Macciocchi, & Ferrara, 2007; Moore, Dwedensen, & Depp, 2017; Gwaltney, Shields, & Shifffman, 2008). The ability of computerised tasks to reduce the confounding impact of motor ability on measures of processing speed is not the only advantage. Compared to tests that require materials, preparation, or long administration times, brief mobile tests allow participants' functioning to be easily captured in real time and in real world environments (Sliwinksi et al., 2018). Mobile tests can be used to monitor impairment over a period of time and places, such as over a night of drinking, concussion during a football game, or at roadside police stops. The impact of learning however needs to be controlled for when conducting tests over multiple sessions with short intervals (Timmers et al., 2004; Hinton-Bayer, Geffen,

& McFarland,1997). This ensures measurements are accurate, detecting real improvements in performance and not improvements from learning.

Computerised tests also allow online scoring greater accuracy of recorded reaction times (Cameron et al., 2001; Noyes, 2008; Schatz & Zillmer, 2003). Due to mobile tasks not being undertaken in controlled lab settings, the increased risk of distractions impairing performance need to be considered when choosing where to undertake mobile tests (Verdejo-Garcia et al., 2019). Those who must undertake multiple tests regularly may have reduced motivation to testing when an administrator is not present (Noyes, 2008). Other concerns include computer and software crashes or poorly designed interfaces which create confusion or anxiety in the user (Schatz & Zillmer, 2013). Studies of mobile tests demonstrate they can overcome these criticisms; showing little difference in regarding presence or absence of a trained practitioner, as well as having good test retest reliability, and efficient administration (Holmlund et al., 2019; Moore et al., 2017; Rao et al., 2017; Tiplady, Oshinowo, Thomson, & Drummond, 2009; Tiplady, 2009).

Processing Speed Tests and Concussion

Neurocognitive test batteries are routinely used in the assessment of concussion on cognition in sports (Schatz & Zillmer, 2003). Concussion results in a variety of symptoms, including deficits to information processing speed, attention, concentration, working memory, and learning (Cossavin & Elbin, 2010; Schatz & Zillmer, 2003; Ozen & Fernandes, 2012). The importance of having tests sensitive to subtle cognitive deficits following head injury allows coaches to prevent players from returning to play even if acute physical symptoms have subsided (Iverson, Lovell, & Collins, 2005; Makdissi et al., 2001; Okonkwo, Tempel & Maroon, 2014; McCroy, Makdissi, & Collie, 2005). Computerised tests, such as the CogState-CogSport, ImPACT, and Concussion Resolution Index, are sensitive measures to identifying the impacts of concussion (Broglio et al., 2007; Schatz & Zillmer, 2003).

Correlations between tasks of processing speed and concussion assessment tasks demonstrate the underlying factor of processing speed is measured and identified by both. The ImPACT was strongly correlated with the SDMT(r=.70), and CogSport had moderate correlations with the DSST (Iverson et al., 2005; Makdissi et al., 2001). The creation of brief neuropsychological tasks that are computerised and mobile can act as a form of screening and baseline tool to follow through the process of concussion recovery.

Sensitivity of Processing Speed Tests

The ability for tests of processing speed to detect when processing is impaired is crucial to having a good measure. As alcohol is a known substance which impairs of speed processing, it is an effective way to bring about impairment in processing speed to be measured (Fillmore, 2007; Kennedy, Turnage, Wilkes, & Dunlap, 1993). The standard quantification of Breath Alcohol Concentration (BrAC), means that impairment at standardised levels can be measured across participants to examine the sensitivity of a particular test (Cash et al, 2015; Fillmore, 2007). Processing speed tests vary in their sensitivity to impairment, as shown in Table 2. There is also variation within tests of processing speed themselves. For example, the DSST shows consistent sensitivity to alcohol at high BrAC, yet significant variation in its' sensitivity to acute doses (Jongen et al., 2016; Moskowitz & Fiorentino, 2000) (See Table 2). This creates a need for a test or set of tests that can be mobile, efficient and quick, sensitive to acute impairment, cost effective, accessible, and have minimal interference of motor dexterity. There is also a growing interest in the use of mobile tests as methods to test clients regularly and out in the field (Verdejo-Garcia et al., 2019).

Aims and hypotheses

We have developed a new computerised test of processing speed, named the Mobile Open Processing Speed test (MOPS). The MOPS is based on a similar logic to the existing pencil-and-paper measures of processing speed such as the DSST, SDMT, and WAIS Symbol Search. It is designed to incorporate all the benefits of computerised testing into to real world environments.

The aim of this study is to validate the MOPS test using existing measures of the processing speed construct (WAIS Symbol Search and SDMT). It also aims to ensure that the MOPS has good test retest reliability and is sensitive to acute effects of alcohol intoxication on processing speed. This study will focus on four hypotheses. Firstly, we hypothesize that if MOPS is a valid assessment of processing speed, it should demonstrate strong correlations with other standard measures of processing speed (WAIS Symbol Search, and SDMT). Secondly if MOPS is a valid assessment of processing speed, it should demonstrate correlations with tasks that processing speed contributes to. The Wickens' model of processing speed leads to the prediction that performance on processing speed tasks should correlate with performance on tests of working memory (N-Back Task). Thirdly, for the task to be useful there should be minimal learning effects over multiple testing sessions. We hypothesize that there will be small magnitude effect sizes for learning effects between two testing sessions conducted 7 days apart. This is hypothesised due to the wide array of available changing stimuli present for each trial. Finally, for the task to be useful practically, we hypothesis that it will be sensitive to the effects of processing-speed impairing substances, such as alcohol.

Table 1
Tests of Processing Speed and their Characteristics

Test	Assesses	Length	Cost	Licensing	Format	Test retest reliability *r*
WAIS IV: Symbol Search	Processing speed. Short term visual memory. Visual- motor coordination and speed. Visual discrimination. Working memory. Attention.	120 seconds	****	C	Pencil and paper	.81
WAIS IV: Coding (Digit Symbol Coding WAIS III) / Digit Symbol Substitution Test	Processing speed. Short-term visual memory. Psychomotor speed. Visual perception. Visual-motor coordination. Visual scanning ability. Attention.	90 seconds	****	C	Pencil and paper, Digital	.86
Woodcock Johnson III: Visual Matching	Perceptual Speed	5-10 minutes	****	C	Pencil and paper	0.70-0.89
Woodcock Johnson III: Cross out	Perceptual Speed	5-10 minutes	****	C	Pencil and paper	0.70-0.89
Woodcock Johnson IV: Rapid Picture Naming	Naming Facility	3 minutes	****	C	Pencil and paper	0.70-0.89
Woodcock Johnson IV: Pair Cancellation	Attention. Concentration	3 minutes	****	C	Pencil and paper	0.60-0.69
Symbol Digit Modalities Test	Processing speed. Short-term visual memory. Psychomotor speed. Visual perception, motor coordination, and scanning ability. Attention.	90 seconds	***	C	Pencil and paper, Verbal, Digital,	0.80, 0.76

Computerised Test of Information Processing	Reaction Time.	15 minutes	***	C S B M	Digital	-
Paced Auditory Serial Addition Test	Processing Speed. Working Memory. Divided Attention. Mental Arithmetic	10 – 15 minutes	***	C	Auditory	0.90 – 0.97
Inspection Time Task	Processing Speed	25 minutes	-	C	Pencil and paper, Verbal	-
NIH Toolbox Battery: Pattern Comparison Speed Test	Processing Speed	90 seconds	***	C	Digital	0.73. - 0.84
NIH Toolbox Battery: Oral Symbol Digit Test	Processing Speed	120 seconds	***	C	Digital, Verbal	-
Useful Field of View task	Visual processing speed. Divided attention. Selective attention	5-10 minutes	-	B	Digital	-
Subtle Cognitive Impairment test (SCIT)	Perceptual judgments	5 minutes	-	-	Digital	0.98 Split half r=0.83
Automated Neuropsychological Assessment Metrics: CogSport Battery	Reaction time, processing speed. Working memory. Short term memory. Learning. Problem solving. Attention. Spatial abilities	15-20 minutes	**	C M	Digital	0.76
Headminder Concussion Resolution Index	Reaction time. Decision making	20-25 minutes	***	C M	Digital	ICC = .15-.66
Immediate Post Concussion Assessment and Cognitive Testing (ImPACT)	Processing speed. Attention. Memory. Reaction time	20-15 minutes	***	C M B	Digital	ICC = 0.76-0.85

Note. Cost of testing represented by ** = $10's. ***=$100's. ****=$1000's
Licencing Codes required to administer the test: C = Registered Psychologist. S = Speech Pathologist. B = Allied Health or Special Education Professional. M = Medical Professional.
- = information unavailable/inaccessible

Table 2

Effects of Alcohol Performance from 0.00 Breath/Blood Alcohol Concentration on Tests of Processing Speed.

Author	Sample Size	Tests	Measure	0.01-0.049 BrAC	0.05 BrAC	0.05-0.079 BrAC	0.08 BrAC	0.08-0.099 BrAC	0.10+ BrAC
Cash et al. (2015)	19	Digit Symbol Substitution Task (DSST) digital ITT	DSST RT		= ↓		↓		
			DSST Errors		=		↓		
			ITT		↓		↓		
Cameron, Sinclair, and Tiplady (2001)	47	DSST (pencil) DSST (digital Pen C)	DSST N. correct					↓	
			DSST N. incorrect					↓	
			DSST digital RT					↓	
			DSST digital N. incorrect					↓	
Dry et al. (2012)	56	ITT Useful Field of View (UFVO)	ITT		↓		↓		↓
			UFVO		=		↓		↓
Fillmore and Van Selst (2002)	12	Reaction time dual task interference	RT task		↓			↓	

Author	Sample Size	Tests	Measure	0.01-0.049 BrAC	0.05 BrAC	0.05-0.079 BrAC	0.08 BrAC	0.08-0.099 BrAC	0.10+ BrAC
Friedman, Robinson, and Yelland (2011)	21	Subtle Cognitive Impairment Test (SCIT) digital	SCIT RT	=	=				
			SCIT errors Female	↓	↓				
			SCIT errors Male	=	=				
Kennedy et al. (1993)	21	Code Substitution.	Code		=				=
		4 Choice React Time Task.	4 Choice RT		=				=
Maylor and Rabbitt (1993)	Literature Review- 8 studies	Simple Reaction Time, Choice Reaction Time	Simple RT			1 ↓			
			Choice RT			3 ↓	1 ↓	1 ↓	
Moskowitz and Fiorentino (2000)	Literature Review	DSST CFF	DSST Unimpaired	13 =	1 =	3 =	1 =	1=	
			DSST Impaired.	2 ↓	1 ↓	7 ↓	1 ↓	3 ↓	
			CFF	6 =		9 =			3 ↓

Author	Sample Size	Tests	Measure	0.01-0.049 BrAC	0.05 BrAC	0.05-0.079 BrAC	0.08 BrAC	0.08-0.099 BrAC	0.10+ BrAC
Tzambazis and Stough (2000)	16	ITT Simple RT. Complex RT. WAIS-R Digit Symbol	ITT		↓				
			Simple RT		↓				
			Complex RT		↓				
			WAIS Digit Symbol		=				
Jongen et al. (2016)	Literature review 37 studies	DSST UFOV 4 Choice Reaction Time Simple Reaction Time. Complex Reaction Time	DSST	1 =		4 ↓ 7 =		16 ↓ 1 =	
			UVFO			1 =		2 ↓ 1 =	
			4 Choice RT	1 =		5 ↓ 4 =		6 ↓	
			Simple RT	1 =		4 ↓ 4 =		2 ↓ 2 =	
			Complex RT Test			2 =			
Tharper et al. (1995)	12	DSST	DSST		↓				

Note: ↓ (worse performance); = (equal performance or non-significant difference); ↑ (better performance)
Zoethout et al. (2011) literature review of 190 studies was not stratified by breath alcohol concentration. Results are included here: In DSST like tests: 61 studies ↓, 29 =, 0 ↑. In Reaction time tests: 53 studies ↓, 47 = and 0 ↑

Study 1 Method: MOPS validation against traditional processing speed measures and examination of test retest reliability.

Participants

Sixty-eight participants were recruited from the general community through social media and flyer advertisements. Inclusion criteria included: aged between 20 and 64; English as a first language; normal, or corrected-to-normal vision. Exclusion criteria included: self-reported mental health condition; major physical health complaints; current psychoactive medication; English as a second language. Participants were offered $10AUD reimbursement per testing session, to a total of $20AUD.

Materials

Mobile Open Processing Speed* Test *(MOPS). This was designed as an analogue of the traditional pencil-and-paper Symbol Search task, presented on Android tablets and programmed in Presentation® software (Neurobehavioral Systems, 2019). Participants are presented with a screen displaying two 'target' images at the top in a grey box, and a white box with 6 'array' images below (See Figure 2.1). Images consist of combinations of both an inside and outside shape. There are four possible outside shapes, square, circle, triangle, and hexagon, and 90 possible inside shapes. Participants respond YES if *either* of the two target images are present in the array of images below; or NO if *neither* of the two target shapes are present. Only one of the target images is ever present in the array, never both. The location of a present target in the array is counterbalanced randomly each trial, to prevent continuous repetition of a target location.

There are 4 classes of trials: easy no-match, easy match, difficult no-match, and difficult match. The class of trial is created by the presence or absence of lures and the difficulty of distractors. Lures occur when an *inner* shape of an array image matches the inner shape of a target image, but does not match the outside shape of the "other target" (i.e. the

target that is not repeated as an inner match) (See Figures 2.3; 2.4). Difficult trials include lures, easy trials do not. Distractors are the remaining images in the array that are not accounted for as lures or matches. Easy distractors *differ* from the two target images in *both* inner and outer shape. Easy distractors are only used in easy trials (See Figures 2.1; 2.2). Difficult distractors differ from both the two targets in *inner* shape. All four outer shapes (hexagon, circle, triangle, and square) occur in the array. This results in two of the distractors overlapping in *outer* shape with both of the target outer shapes. Difficult distractors are only used in difficult trials (See Figures 2.3; 2.4). Within one test session, each class of trial appears 4 times in a randomised order, to a total of 16 trials; this equates to 50% of trials requiring YES response and 50% NO response.

The HOLD button on the MOPS task is used to initiate the presentation of the stimuli. Participants place their finder on the HOLD button to bring up the images, only removing their finger to select their response (YES/NO); returning to HOLD to bring up the next set of images. This was implemented to prevent participants from hovering over an answer, potentially skewing reaction time to particular a response. The time between the presentation of stimuli and removing finger to respond is information processing speed or 'decision time'. While the time between removal of finger from HOLD button and tapping a response is a measure of the movement motor component. This allows processing speed to be separated out from response motor time; and can effectively reduce most of the motor issues from the task.

Two dependent variables were measured for the MOPS task: reaction time to correct trials and number of errors. Reaction time to correct trials (RTC) was used instead of overall reaction time (RT). RTC allows a measure of when information processing has occurred correctly. The inclusion of incorrect responses in RT may include responses where participants responded randomly, not going through the information processing process.

Distinguishing between if a wrong response was due to incorrect processing or random responding is not possible in the overall RT measure; therefore, the use of RTC measure allows a measure of when processing occurred correctly.

Figure 2.1. Easy No-Match Trial of MOPS Test

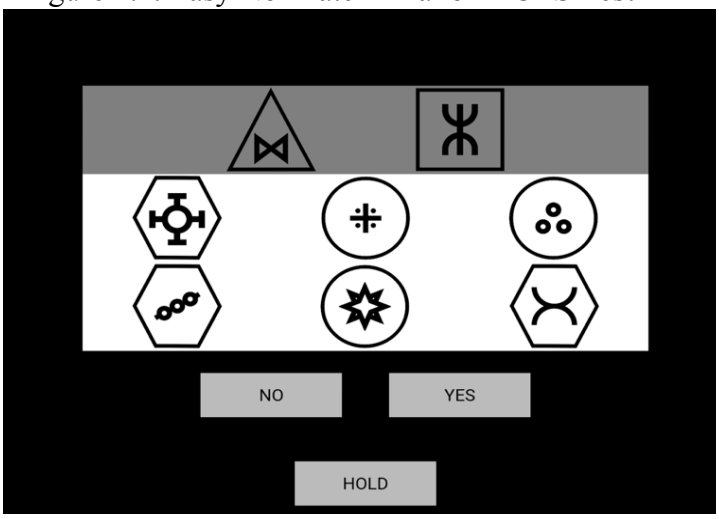


Figure 2.1. An easy no-match trial of the MOPS task. Created by having no target match. No lures. All distractors in the array differ from the two targets in both inner and outer shape.

Figure 2.2. Easy Match Trial of MOPS Test

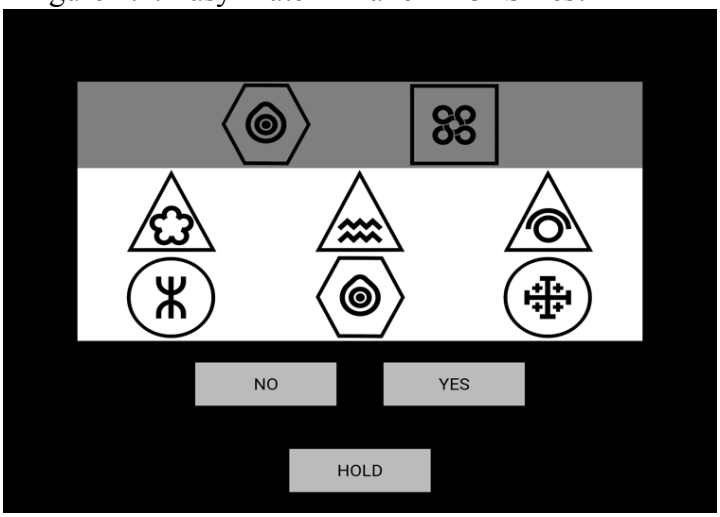


Figure 2.2. An easy match trial of the MOPS task. Created by having one target match in the array. No lures. Remaining distractors in the array differ from both target images in both inner and outer shape.

Figure 2.3. Difficult No-Match Trial of MOPS Test

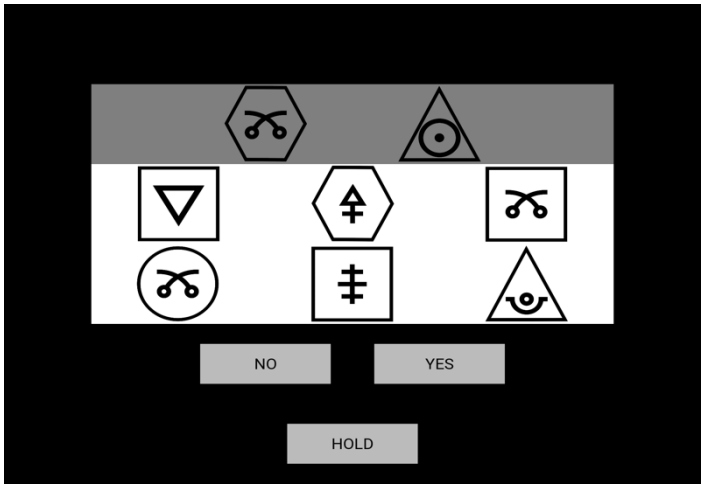


Figure D. A difficult no-match trial of the MOPS task. Created by having no target match. Two lures. Remaining 4 difficult distractors differ from targets in inner shape. Presence of all four outer shapes in the array.

Figure 2.4. Difficult Match Trial of MOPS Test

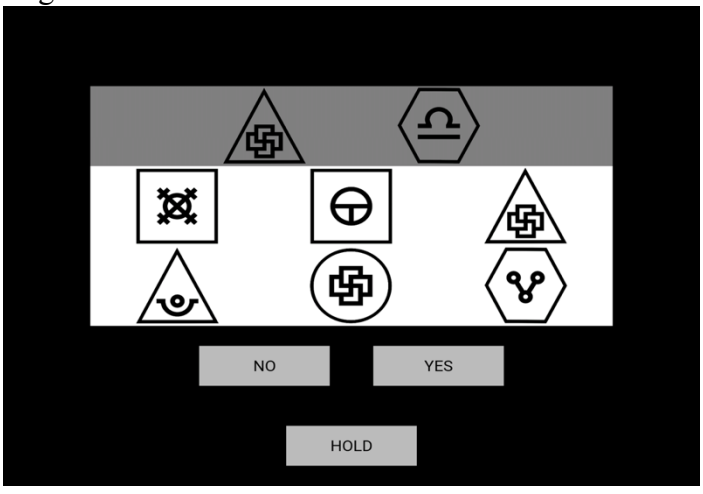


Figure 2.3. A difficult match trial of the MOPS task. Created by having one target match. One lure. Remaining 4 distractors differ from both targets in inner shape. Presence of all four outer shapes in the array.

WAIS Symbol Search (WAIS SS). This is a pencil-and-paper test processing speed measure from the Wechsler Adult Intelligence Scales. There are 60 trials printed in a booklet and participants have 120 seconds to complete as many as possible. A trial consists of two target symbols and an array of five test symbols. Participants must indicate if *either* of the two target symbols are present in the test array; marking the either the target symbol in the array or the NO response as appropriate. One dependent variable was measured for the WAIS SS task: Total score (correct scores minus incorrect scores).

Symbol Digit Modalities Test (SDMT). This is a processing speed measure, chosen as it was designed as a pencil-and-paper task that has been adapted to a mobile version in the Penscreen software package for Android tablets. In the task, a reference key is presented at the top of the screen with the numbers 1 – 9 and each with a corresponding symbol. Symbols are presented sequentially (87 trials) at a central fixation point. Participants respond by tapping the corresponding digit to the presented central symbol at the bottom of the screen as quickly as possible.

Two dependent variables were measured for the SDMT task: reaction time to correct trials, and number of errors.

N-Back Task. A test of working memory, completed in the Penscreen software package for Android tablets. Letters are presented sequentially at a central fixation point once per second. Participants are instructed to decide if the current letter is the same as the letter *N* letters ago. The *N* is either 1, 2, or 3 letters back depending the level being completed, with each level of difficulty completed sequentially in blocks. There were 12 targets in the 1-back task, and 24 in the 2-back and 3- back tasks. Targets are randomly presented at a probability of 10%. Two dependent variables were measured for the N-Back tasks: reaction time to correct trials, and number of errors.

Wechsler Test of Adult Reading (WTAR). A test of general cognitive function. Participants are asked to pronounce a list of 50 English words with irregular grapheme-to-phoneme correspondence. Correctness is recorded. The test was co-normed with the WAIS and scores correlate with WAIS III Full-Scale IQ scores (r=.73) (Strauss, Sherman, & Spreen, 2006; Mathias, Bowden, & Barrett-Woodbridge, 2007).

User Experience Questionnaire, Short-Form (UEQ). This assesses participants' immediate impression about their user experience of tests. Participants respond to 8 items related to user experience of the MOPS and WAIS SS on a 7 point Likert scale. The items are divided into pragmatic (complicated, confusing, inefficient, obstructive) and hedonic (boring, uninteresting, conventional, usual) subscale scores (Schrepp, Hinderks, & Thomaschewsji, 2019) (Appendix A)

Procedure

Ethics was approved by the Tasmania Social Sciences Human Research Ethics Committee. Approval reference number: H0018073 (Appendix B).

Interested participants were directed to complete an online screening questionnaire to assess their eligibility (Appendix C). Eligible participants were invited to join the study, following an information sheet and consent form (Appendix D; Appendix E) The study was conducted over two sessions approximately 7 days apart (minimum 5 days, maximum of 14). The first session was roughly 45 minutes in length, the second session roughly 30 minutes.

In the first session participants completed the WTAR and general demographic survey. Participants then completed the battery of tests in the subsequent order: MOPS, WAIS SS, SDMT, and 1-, 2- and 3-Back tasks. Following completion of the MOPS and the WAIS SS participants completed the SUEQ for these tasks. The second session was completed approximately 7 days after the first. Participants completed the cognitive test

battery in matched order in the second session, excluding the WTAR and general demographic survey.

Data Analysis

Concurrent validity between MOPS and other measures of the processing speed construct were assessed by Pearson correlations. Test-retest reliability and learning effects were assessed using Pearson correlations and paired-samples t-tests between performance on Sessions 1 and 2. Nunally's (1978) recommendation for acceptable standard of reliability (r=0.70) and adequate standard of reliability (r=0.80) were used when examining test retest reliability. Inferential analyses were supplemented by effect sizes and Bayes Factors; all analyses were conducted in Jamovi 1.1.5. Due to technical malfunction, one participant's retest MOPS data was missing and so was excluded. Reaction Time Correct trials (RTC) on the MOPS task were also missing for one participant, and so excluded.

Study 1 Results

Sample Characteristics

The sample comprised of 68 participants (28 Male) aged 20 to 63 years old (M=42.4, SD=13.7, Missing = 10). Participants were recruited across a spread of age groups (see Table 3). 41.8% of participants' highest level of education was a completed University degree (including honours); with 20.9% currently completing a university degree. Mean WTAR score across all age groups was 43.4 (5.36) (see Table 3).

Table 3

Demographic Characteristics of Study 1 Sample (N=68)

	Age		N			WTAR[a]	Education[b]					
Age Group	Mean (SD)	Missing Age	Male	Female	Total	Mean (SD)	1	2	3	4	5	6
20 – 29	23.4 (1.92)	6	11	11	22	41.5 (3.92)	0	1	1	12	4	3
30 – 39	35.3 (2.61)	0	2	8	10	41.2(6.07)	0	0	3	0	6	1
40 – 49	44.8 (2.79)	1	5	10	15	44.7 (4.27)	1	1	2	2	9	0
50 – 64	56.0 (2.65)	3	8	9	17	44.6 (5.69)	1	1	4	0	6	5
60 – 64	61.6 (1.74)	0	2	2	4	49.3 (7.72)	0	0	0	0	3	1

Note.
SD = Standard Deviation; N= Number
[a] WTAR = Wechsler Test of Adult Reading.
[b] Highest level of education completed: 1= Year 10; 2= Year 12; 3= TAFE/training; 4 = Currently completing university degree; 5= University degree (inc. honours); 6= Postgraduate degree (Masters, PhD).

Correlation of MOPS with other measures of processing speed.

The MOPS correlated strongly with other measures of processing speed *(r*=-0.69 with WAIS SS Total score, and *r*=0.74 with SDMT RTC). These relationships were largely consistent on retest (Table 4). There were moderate negative correlations between the WAIS SS Total score and SDMT RTC in session 1, increasing on retest. These correlations between processing speed measures are consistent with other studies (Hinton-Bayer & Geffen, 2005; Rao et al., 2017; Slwinski et al., 2018).

The MOPS correlated moderately with tests of working memory (N-Back RTC *r*=0.39) (Table 4). This was similar to the performance of other tests of processing speed with tests of working memory (Conway et al., 2002; Sliwinski et al., 2018).

Table 4

Correlations between the MOPS measures and other measures of processing speed at Test (top right) and Retest sessions (bottom left)

	Measure	1	2	3	4	5	6	7
1	MOPS RTC	-	-0.17	-0.48***	0.71***	-0.11	0.14	-0.22
2	MOPS Error	-0.42***	-	0.08	-0.05	0.16	-0.11	-0.04
3	WAIS SS Total	-0.69***	0.30*	-	-0.57***	0.06	-0.41***	0.28**
4	SDMT RTC	0.74***	-0.29*	-0.70***	-	0.03	0.31**	-0.37**
5	SDMT Errors	-0.23	-0.01	0.07	-0.29*	-	-0.14	-0.07
6	N-Back RTC	0.39***	-0.19	-0.39***	0.41***	-0.24*	-	-0.34**
7	N-Back PC	-0.18	-0.09	0.32**	-0.34**	0.15	-0.35**	-

Note.
*p<.05; ** p<.01; ***p<.001

Objective Measures

MOPS RTC

A paired samples t-test revealed there was a statistically significant moderate magnitude improvement in MOPS Reaction Time for Correct trials (RTC) between test and retest ($p<.001$, $d=0.59$) (Table 5). Bayes Factors revealing strong evidence in favour of this alternative hypothesis of an effect (Table 5). Correlations between test and retest for MOPS RTC revealed evidence for acceptable test retest reliability ($r=0.80$). Examination of individual level change in RTC showed that the changes were largely consistently improvements between test and retest across participants (See Figure 3).

MOPS Errors

A paired samples t-test revealed there was a non-significant weak magnitude improvement in MOPS errors between test and retest ($p=0.272$, $d=0.14$), with Bayes Factors revealing evidence in favour of this alternative hypothesis of an effect (Table 5). Correlations between test and retest for MOPS errors revealed evidence for unacceptable test retest reliability ($r=0.36$). Examination of individual level change in MOPS Total Errors showed that the changes varied in improving and decreasing between test and retest across the score range (See Figure 4). Examination of two participants in Figure 4, shows participants made 16/16 errors in the first session. This response rate is higher than chance, as pressing only one button throughout the session would result in a total of 8 incorrect answers. It is likely the participants misunderstood the instructions, responding with opposite buttons; and the researcher failed to confirm adequate participant understanding of the task before administration. Researchers must ensure participants repeat explanations back in their own words to confirm understanding and prevent errors like this occurring.

WAIS SS Total

A paired samples t-test revealed there was statistically significant large magnitude improvement in Symbol Search score between test and retest (d=-0.87, p<0.001), with Bayes Factors revealing strong evidence in favour of this alternative hypothesis of an effect (Table 5). Correlations between test and retest revealed acceptable reliability *(r*=0.69). Examination of individual level change showed that WAIS SS Total score changes were largely consistently improvements between test and retest across the score range (See Figure 5).

SDMT RTC

A paired samples t-test revealed there was a statistically significant large magnitude improvement in RTC in SDMT between test and retest session (*p*<.001, *d*=1.39), with Bayes Factors revealing strong evidence in favour of this alternative hypothesis of change (Table 5). Correlations between test and retest revealed acceptable reliability (*r*=0.90). Examination of individual level change show that changes in SDMT RTC were consistent improvements between test and retest sessions across participants (See Figure 6).

SDMT Errors

Paired samples t-test also revealed there was a statistically significant weak magnitude improvement in percentage of errors made in SDMT between test and retest session (*p*=0.044, *d*= -0.25) (Table 5). Correlations between test and retest were not acceptable (*r*=0.36). Examination of individual level change, showed the percentage of errors had minimal change, with majority increasing under 5% (See Figure 7).

N –Back RTC

A paired samples t-test revealed there was a statistically significant weak magnitude improvement in RTC and % correct scores between sessions for N-Back, (*p*=0.007, *d*=0.340; and *p*=0.012, *d*=-0.31) (Table 5). Correlations between sessions were not acceptable for RTC (*r*=0.61) or percent correct (*r* =0.30).

Table 5

Core Results of the Processing Speed and Working Memory Measures.

	Test Session	Retest Session	Paired Samples t-test				Bayesian Factors		Test Retest Correlation	
Measure	M (*SD*)	M(*SD*)	*t*	df	*p*	*d*	BF01	BF10	*r*	*p*
MOPS										
RTC (ms)	3225.77 (843.79)	2919.49 (809.06)	4.72	64	<.001	0.59	0.000723	1382.66	0.80	<.001
Errors (n)	3.69 (3.16)	3.26(2.19)	1.11	64	0.272	0.14	4.10	0.244	0.36	0.003
WAIS										
Total (n)	37.81 (6.01)	42.71 (7.70)	-7.16	67	<.001	-0.87	< -1,000	>1,000	0.69	<.001
SDMT										
RTC (ms)	1503.66 (231.06)	1360.66 (200.70)	11.48	67	<.001	1.39	< -1,000	>1,000	0.90	<.001
Percent Errors (%)	0.005 (0.01)	0.009 (0.02)	-2.06	67	0.044	-0.25	1.03	0.958	0.36	0.003
N Back										
RTC (ms)	624.09 (76.73)	619.60 (74.91)	2.80	67	0.007	0.34	0.21	4.75	0.62	<.001
Percent Correct (%)	0.68 (0.13)	0.72 (0.12)	-2.58	67	0.012	-0.31	0.35	2.84	0.30	0.013

User Experience Questionnaires

User experience questionnaires assessed participants' immediate impression of the MOPS and WAIS SS. Paired samples t-test revealed no significant differences between MOPS and WAIS SS on overall score, pragmatic scores, or hedonic scores. Neither of the the tests was more liked than the other. Overall they were closer to the positive end of the scale, and on the subscales in the more neutral range (see Table 6).

Table 6

User Experience Questionnaire comparisons of the MOPS and WAIS SS.

UEQ measure	MOPS Mean	WAIS Mean	Mean difference	*t*	df	*p*
Overall Scores	39.33	39.92	-0.59	-.736	63	.465
Pragmatic Scores	20.0	20.67	-0.67	-1.41	63	.165
Hedonic scores	19.33	19.25	0.78	.156	63	.876

Note. Overall score combines pragmatic and hedonic scores. Pragmatic consists of scores of: complicated, confusing, inefficient, and obstructive measures. Hedonic consists of scores of: boring, uninteresting, conventional, and usual measures. Maximum score of 48. Higher scores indicate more positive answers; middle range scores = neutrality; score of 0 = negative answers.

Figure 3. Visualisation of Change in MOPS Reaction Time between Test and Retest Sessions.

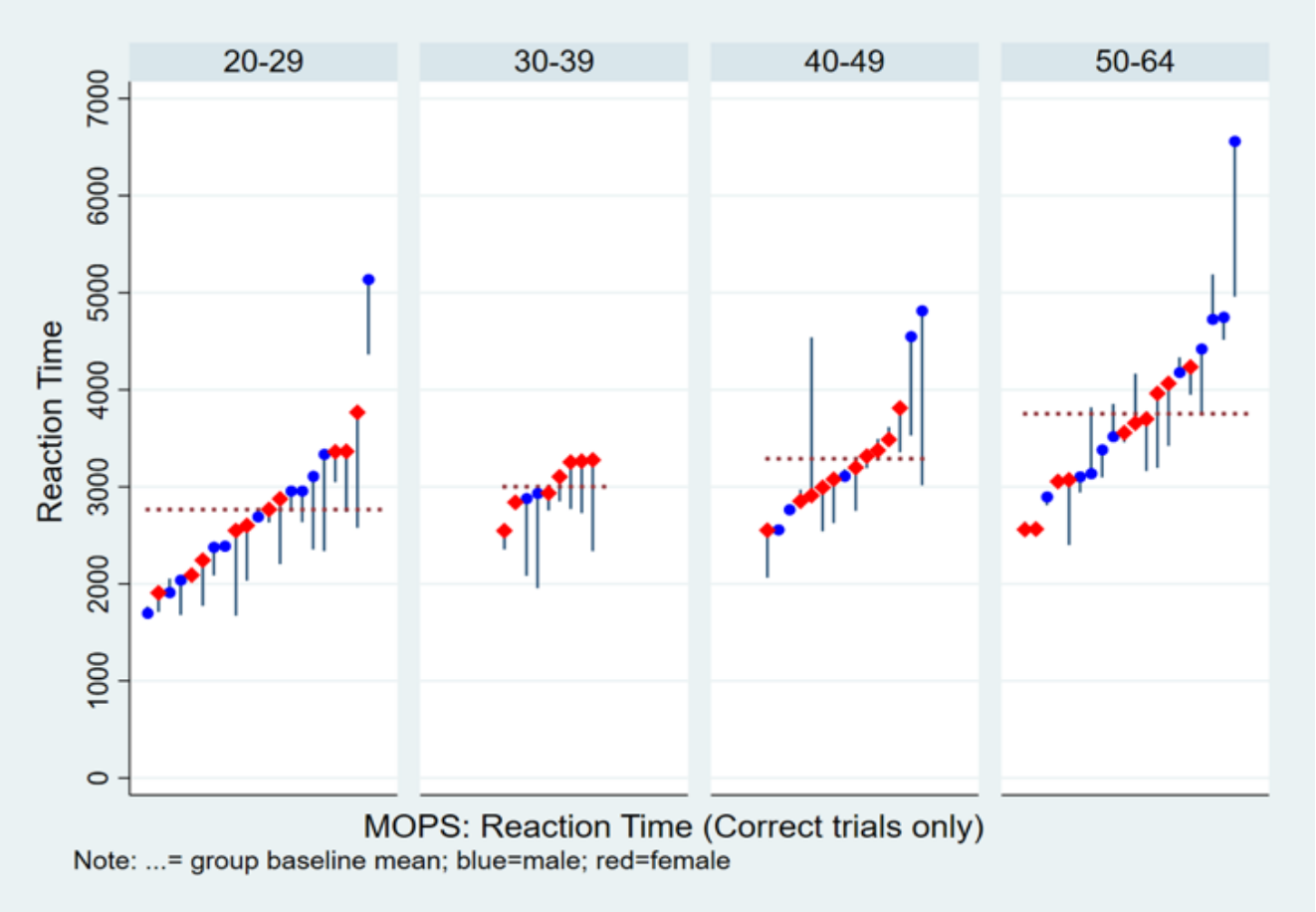


Figure 3. Visualisation of the change in MOPS reaction time between test and retest sessions. Lines indicate direction of change from test session.
…= group baseline mean; blue = male; red = female.

Figure 4. Visualisation of change in MOPS errors between Test and Retest Sessions.

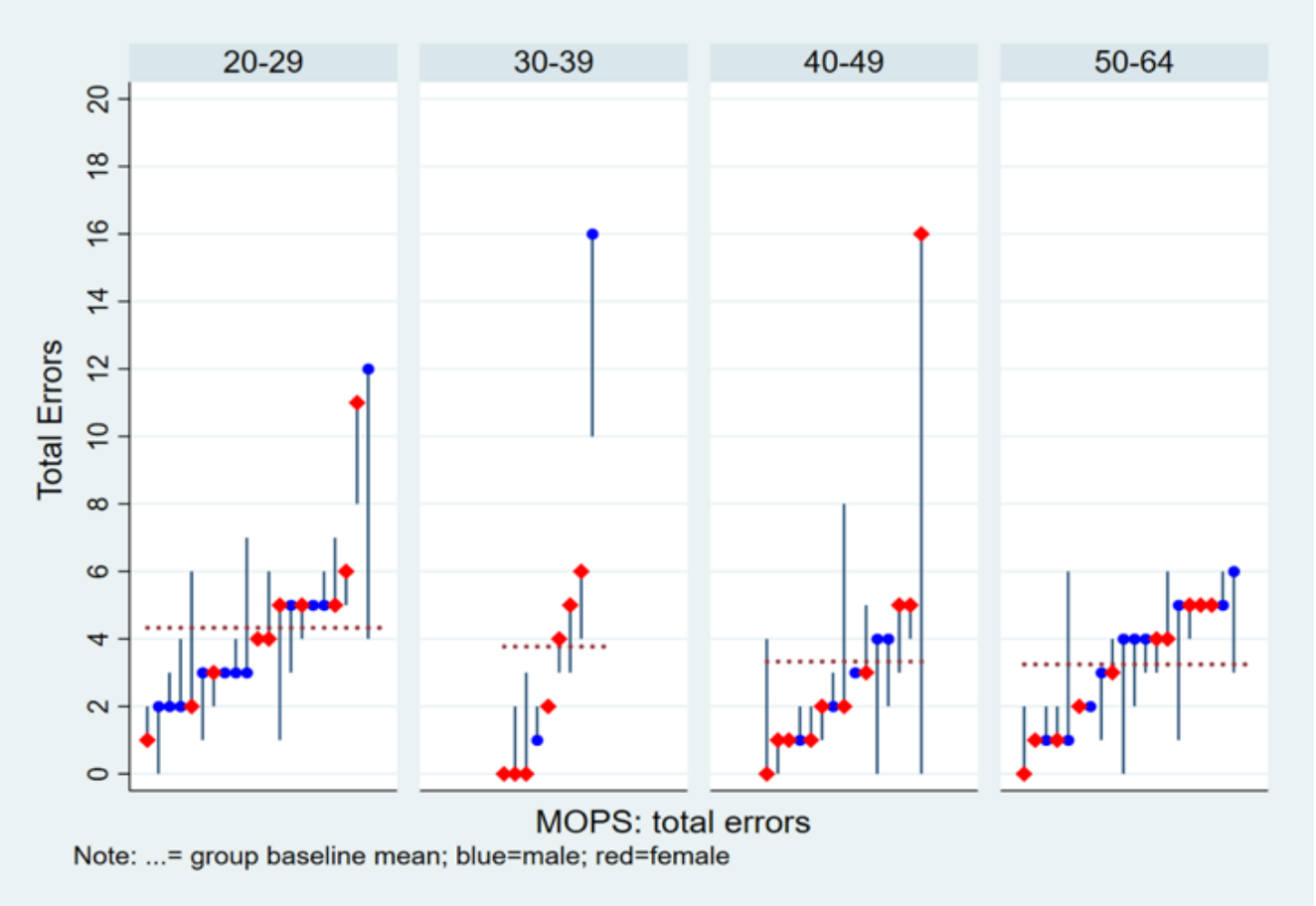


Figure 4. Visualisation of the change in MOPS errors between test and retest sessions.
Lines indicate direction of change from test session.
…. = group baseline mean; blue = male; red = female.

Figure 5. Visualisation of change in WAIS SS Total score between Test and Retest Sessions.

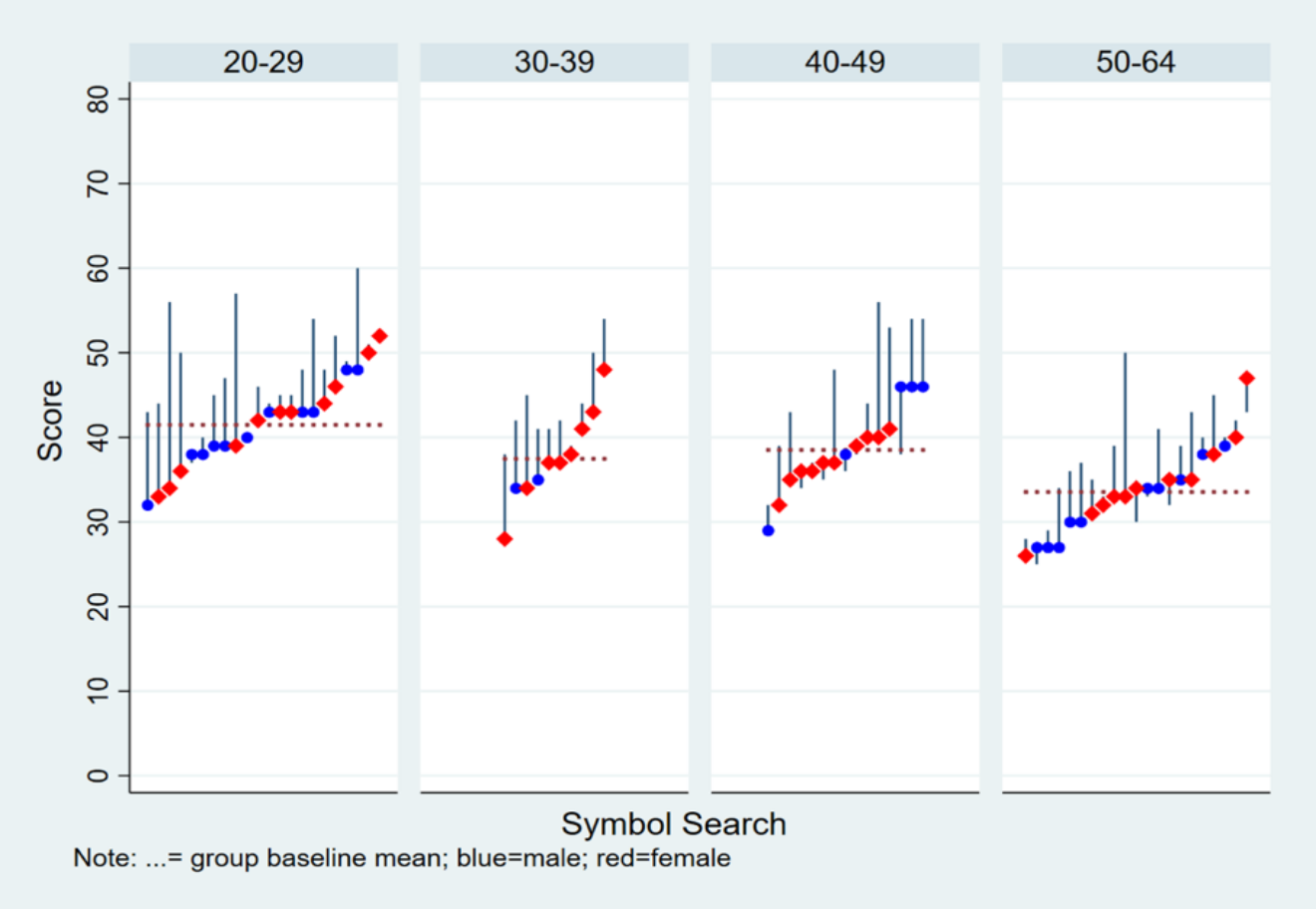


Figure 5. Visualisation of the change in WAIS SS Total score between test and retest sessions. Lines indicate direction of change from test session.
…. = group baseline mean; blue = male; red = female.

Figure 6. Visualisation of change in SDMT RTC between Test and Retest Sessions.

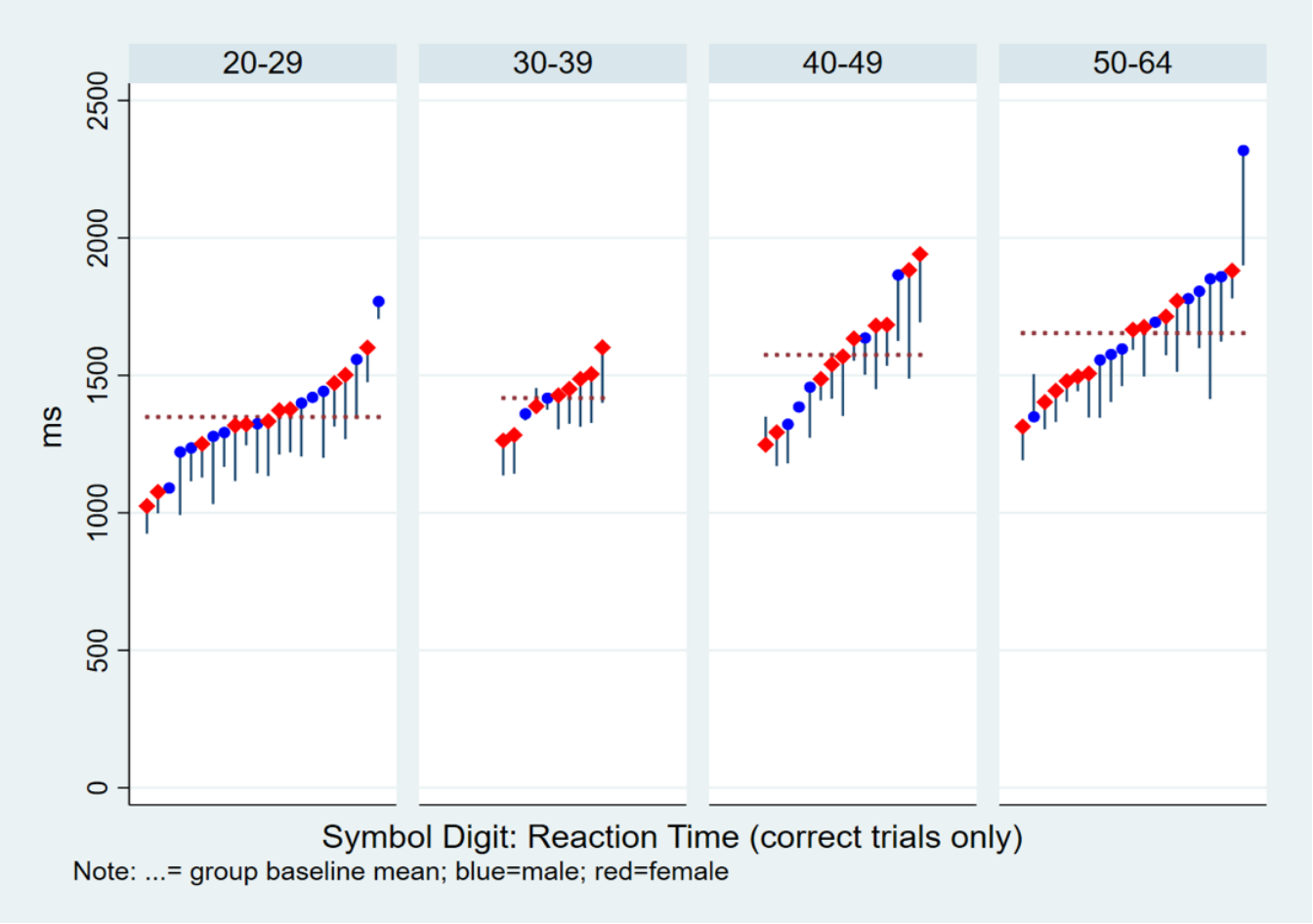


Figure 6. Visualisation of the change in SDMT RTC between test and retest sessions.
Lines indicate direction of change from test session.
…. = group baseline mean; blue = male; red = female.

Figure 7. Visualisation of change in SDMT Errors between Test and Retest Sessions.

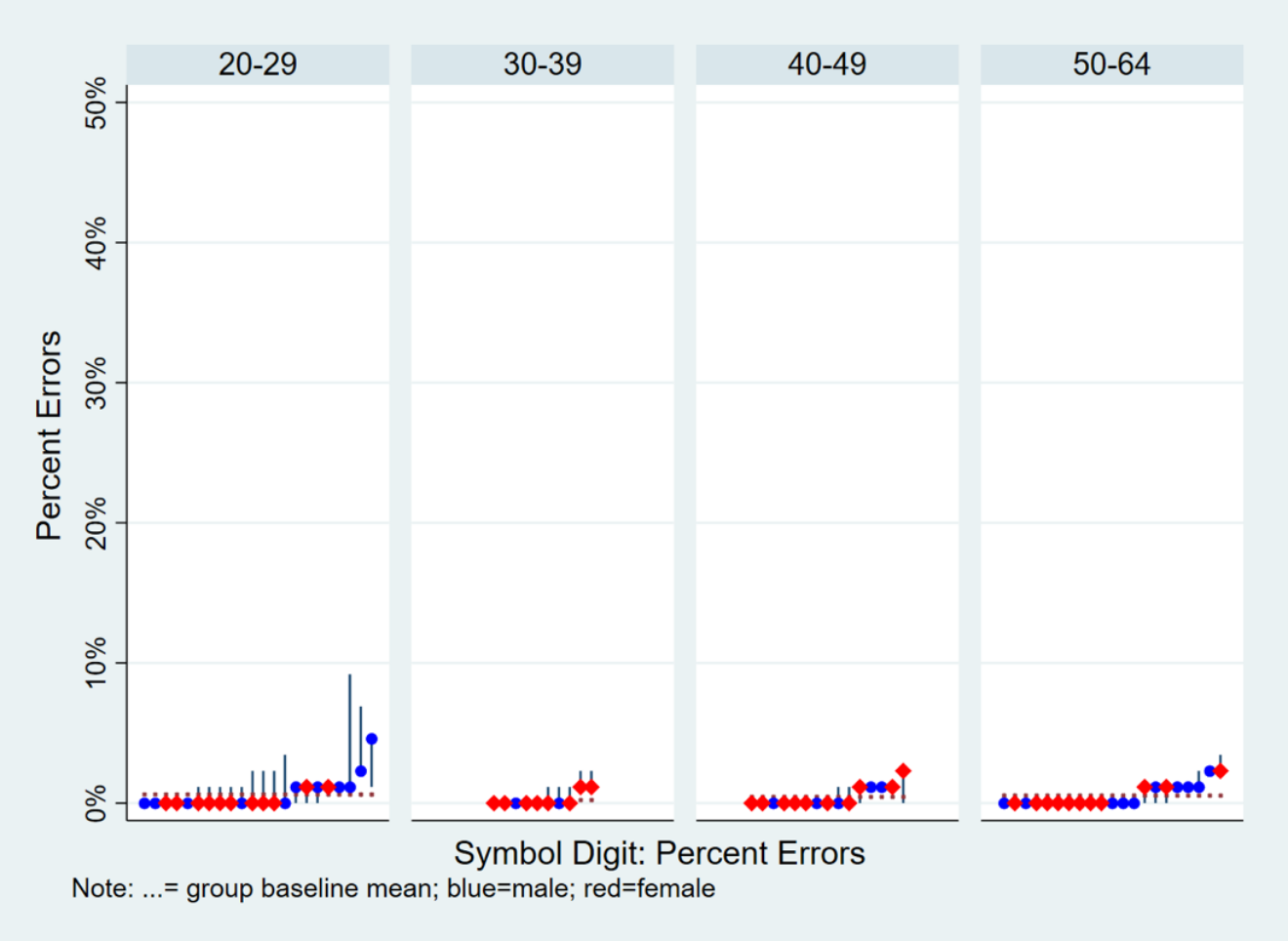


Figure 7. Visualisation of the change in SDMT errors between test and retest sessions.
Lines indicate direction of change from test session.
…. = group baseline mean; blue = male; red = female.

Study 2 Method: Testing MOPS for sensitivity to acute alcohol intoxication

Participants

Thirty-six participants were recruited from the general community through social media, and advertisements at the University of Tasmania. Inclusion criteria included: age between 18 and 34; English as a first language; normal, or corrected-to-normal vision; and regular consumption of alcohol (minimum of two standard alcoholic drinks in the month prior to assessment) to ensure administration safety. Exclusion criteria included: self reported mental health condition; clinical distress indicated by a score >25 on the Kessler Psychological Distress Scale (K10) (Kessler et al., 2002); major physical health complaints; English as a second language; potential alcohol use disorder indicated by a score >15 on the Alcohol Use Disorder Identification Test (AUDIT) (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001); regular consumption of tobacco; and currently using illicit drugs or prescription medication. Participants were offered $50AUD reimbursement.

Materials

Four tests were administered across the testing session: Mobile Open Processing Speed test (MOPS), WAIS Symbol Search (WAIS SS), Penscreen Symbol Digit Modalities Test (SDMT), and N-Back Task. These tasks are described in full in Study 1 above.

Treatment Dose

Treatment dose was made up of vodka (Smirnoff Vodka, 37.5%), mixed with 300mL of tonic water, and 100mL raspberry syrup. Volume of alcohol was calculated for each participant using the Widmark equation to raise participants Breath Alcohol Concentration (BrAC) to a peak of 0.08%. BrAC was measured using a Andatech AlcoSense Prodigy S police grade breathalysers, AS3547.

Procedure

Ethics was approved by the Tasmania Social Sciences Human Research Ethics Committee. Approval reference number: H0016125 (Appendix F)

Interested participants were directed to complete a screening questionnaire (Appendix G). Eligible participants were invited to complete an approximately 240-minute session, following information and consent forms (Appendix H; Appendix I). At baseline (0.00 BrAC) participants completed the MOPS twice to reduce any learning effects; and the WAIS SS, SDMT, and N-Back in sequence. The recommendations set by the National Advisory Council on Alcohol Abuse and Alcoholism (NIAAA) on administering alcohol in research settings were followed. Treatment dose was encouraged to be consumed in 10 minutes to ensure equal rise of BrAC across participants in given time period. BrAC was assessed every 10 minutes throughout the study following consumption. Batteries of tests were conducted at 4 different BrAC time-points: 0.00 baseline, 0.05 ascending, 0.08 peak, and 0.05 descending.

At BrAC 0.05 ascending only the MOPS and N-Back were completed due to time constraints; in all other BrAC points all tasks were completed as per baseline assessments.

Data Analysis

A mixed models analysis was used to determine performance changes in measures over different BrAC-points (0.00, 0.05 ascending, 0.08 peak, and 0.05 descending). Participants were included as a random factor, using diagonal covariance structure. Pairwise comparisons were adjusted for false error rate using Benjamini & Hochberg procedure.

Additionally, WTAR score and Age were added as controlled covariates to the analysis. A total of six trials on the WAIS SS were prorated. Four of these were prorated to form an estimate of what the score would be with an extra 30 seconds (to a total of 120 seconds). Two were prorated to form an estimate of what the score would be with reduced 30 seconds (total of 120 seconds).

Study 2 Results

Sample Characteristics

The sample comprised of 37 young adults (15 males, 22 females) with a mean age of 22.8 years. Mean self reported alcohol (AUDIT) use was in the low risk range. They reported low psychological distress, average pre morbid intelligence, and had mean Body Mass Index's (BMI) in the average range for adults (Table 7).

Table 7

Demographic Characteristics of Study 2 Sample (*N*=37).

Variable	Mean *(SD)*	Range
Age	22.8 *(3.1)*	18.0 - 31.0
Alcohol use (AUDIT)[a]	6.6*(2.8)*	1.0 - 14.0
Body Mass Index (BMI)[b]	23.9*(3.1)*	18.5 – 31.2
Intellectual functioning (WTAR)[c]	41.6*(4.0)*	29.0 – 48.0
Psychological distress (K10)[d]	15.0 *(4.0)*	10.0 – 28.0

Note. [a] Alcohol Use Disorders Identification Test (AUDIT; Babor et al., 2001) score range is 0–40, with a score of 16 or more indicative of hazardous or harmful alcohol use. [b] Higher body mass index (BMI) indicates a greater body mass, with scores between 18.5 and 24.9 indicating a healthy adult weight range (Australian Government Department of Health, 2014). [c] Wechsler Test of Adult Reading (WTAR) score range is 0-50, with higher scores indicative of higher levels of general pre-morbid intellectual functioning. [d] Kessler Psychological Distress Scale (K10; Kessler et al., 2002) score range is 10–50, with scores of <25 likely to have absence of clinical distress.

Breath Alcohol Concentration

Breath alcohol concentration (BrAC) was obtained at four target points. Baseline BrAC was zero. Mean BrAC was 0.057 (*SD*=0.007) at 0.05 BrAC ascending target; 0.075 (*SD*=0.13) at 0.08 peak BrAC target; and 0.049 (*SD*=0.003) at the 0.05 BrAC descending target (See Figure 8).

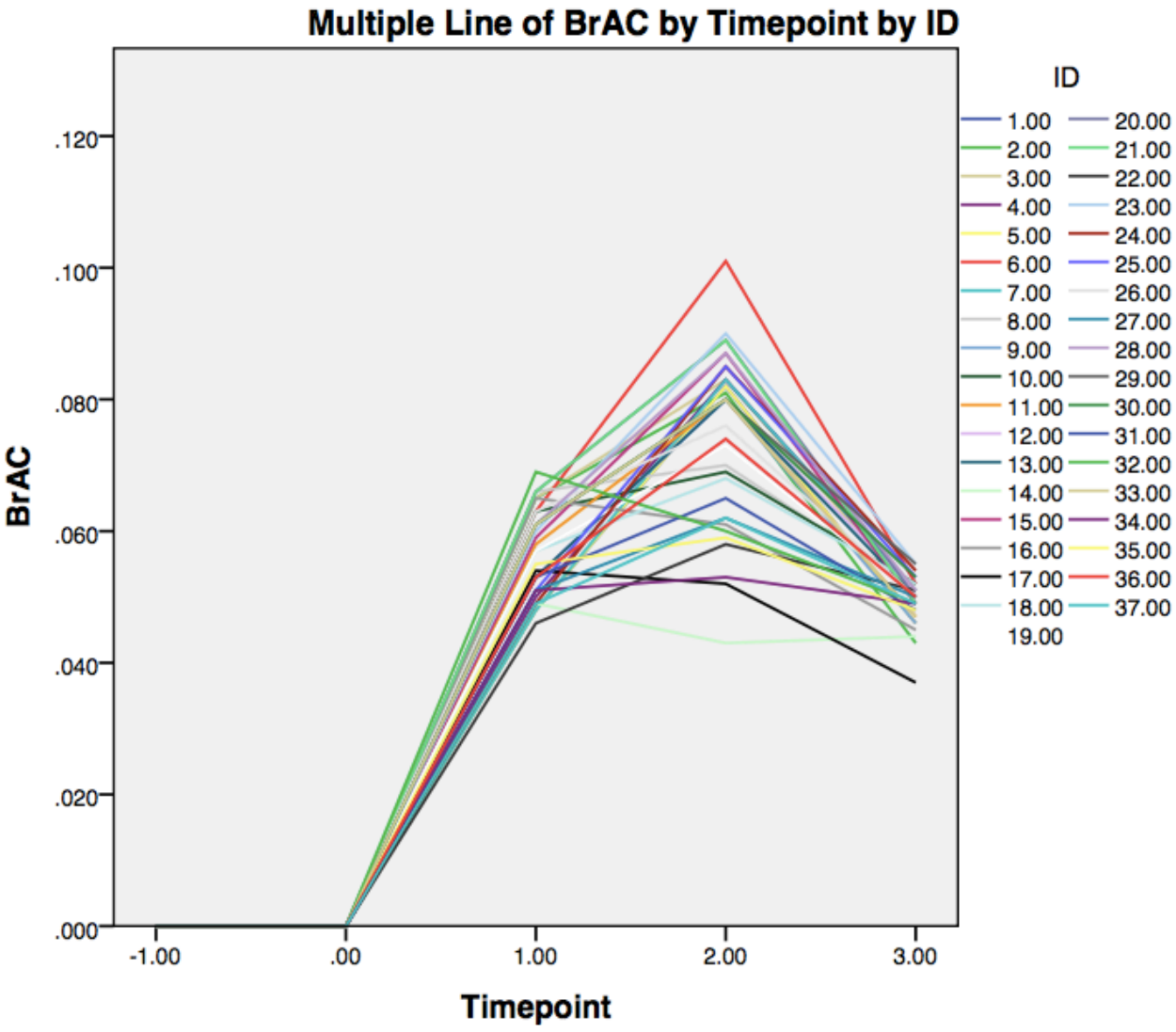


Figure 8. Visualisation of Breath Alcohol Concentration (BrAC) for each participant ID across the the 3 alcohol time-points. -1.00 Practice trial (no BrAC measurement taken); .00 = 0.00 BrAC baseline; 1= 0.05 BrAC ascending; 2= 0.08 BrAC peak; 3= 0.05 BrAC descending.

Objective Measures

MOPS RTC

There was a statistically significant change in MOPS Reaction Time on Correct Trials (RTC) following alcohol consumption (Table 8). Pairwise comparisons reveal that there were *no* significant mean differences in RTC from 0.00 baseline to any of the alcohol time-points (See Figure 9). There was a non-significant weak magnitude increase in RTC from 0.00 baseline to 0.05 BrAC ascending (p=0.118, g= -0.305). There were trivial non-significant decreases in RTC between 0.00 and 0.08 peak BrAC (p=0.118, g=0.276) and 0.00 and 0.05 BrAC descending (p=0.118, g= 0.262). (See Figure 9).

MOPS Errors

There were statistically significant changes in MOPS Errors following alcohol consumption (Table 8). Pairwise comparisons revealed that there were statistically significant moderate magnitude increases in MOPS errors from 0.00 baseline to all three of the alcohol time-points (See Figure 10).

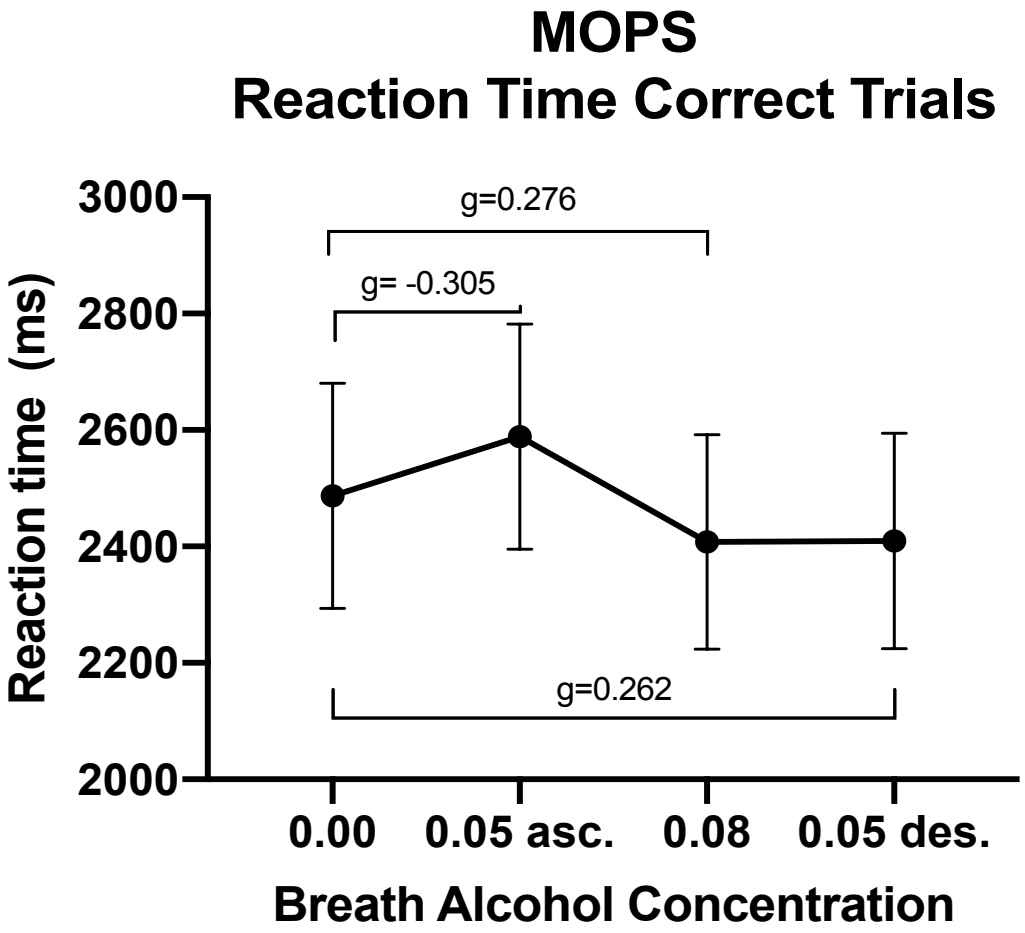


Figure 9. Mean MOPS reaction time to correct trails with 95% confidence intervals and effect sizes at baseline 0.00 and 3 breath alcohol time points.

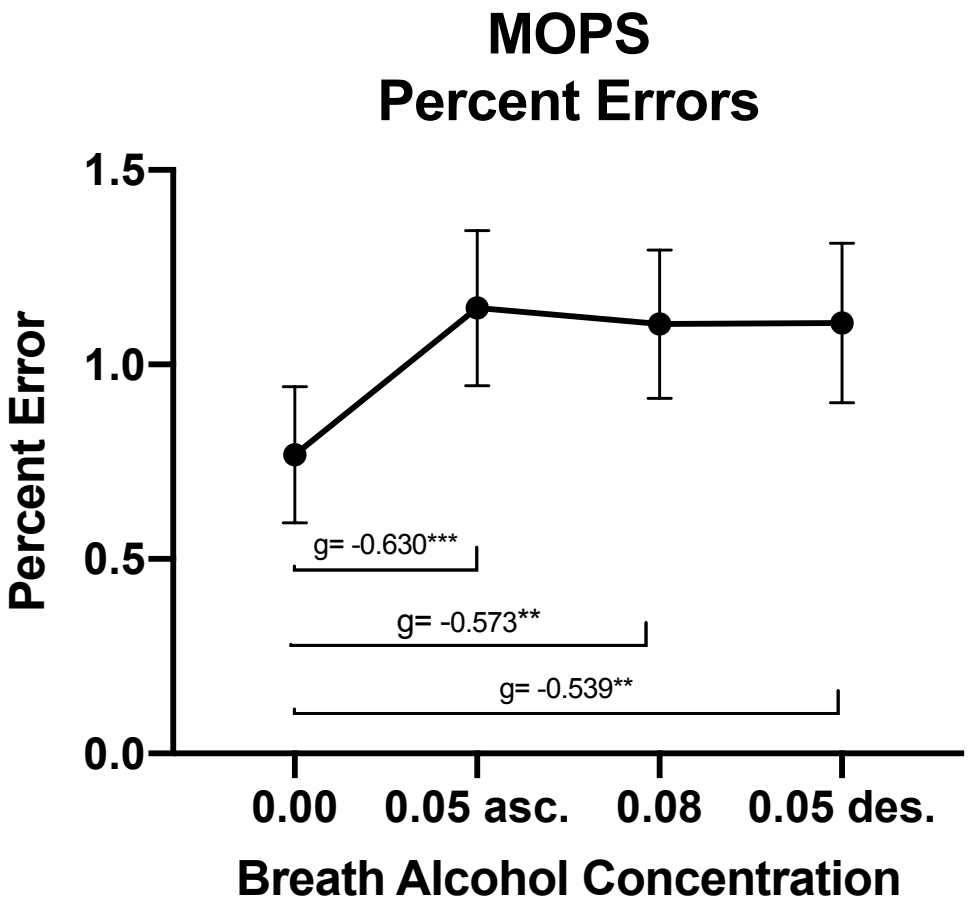


Figure 10. Mean MOPS percent errors with 95% confidence intervals and effect sizes at baseline 0.00 and 3 breath alcohol time points.
**=p<.01; ***=p<.001

WAIS SS

There was a statistically significant change in total WAIS SS scores following alcohol consumption (see Table 8). Pairwise comparisons reveal that there was *no* statistically significant change between 0.00 baseline and 0.08 peak BrAC (p=0.693, g= -0.064) (See Figure 11). Total score significantly *improved* between 0.00 baseline and 0.05 BrAC descending (p<.001, g=-0.889). This increase is not consistent with an impairing effect of alcohol on WAIS performance.

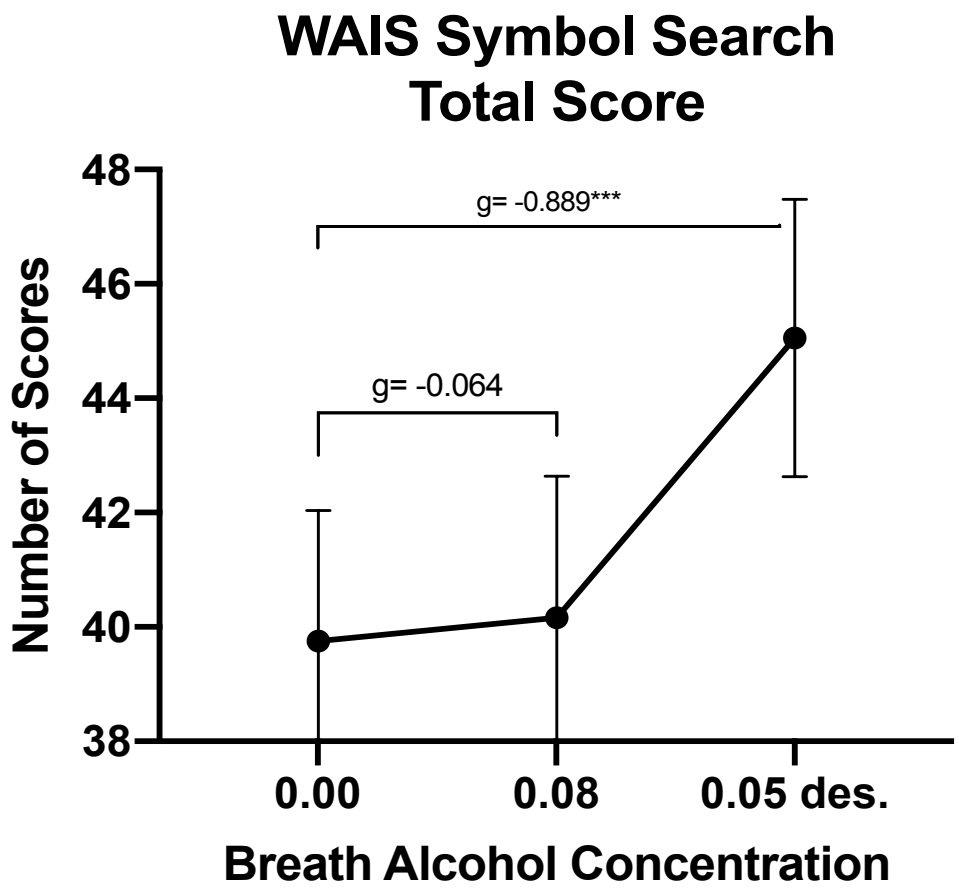


Figure 11. Number of total WAIS SS scores with 95% confidence intervals and effect sizes at baseline 0.00 and 2 breath alcohol time points.
**=p<.01; ***=p<.001

Symbol Digit Modalities Test

There was a statistically significant change in total SDMT RTC following alcohol consumption (see Table 8). Pairwise comparisons reveal that RTC significantly *improved* between 0.00 baseline and 0.05 descending BrAC (p<0.001, g =0.98) (See Figure 12). Overall, no significant change in SDMT percent errors was found following alcohol consumption. However, pairwise comparisons revealed that there was a statistically significant weak increase in errors from 0.00 baseline to 0.08 peak BrAC (p<.05, g =-0.348) (See Figure 13). Errors did not significantly change between 0.0 baseline and 0.05 BrAC descending (p=115, g=-0.268). This improvement in RTC and no equivalent change in errors, is not consistent with a speed accuracy trade off, it reveals an acute tolerance effect.

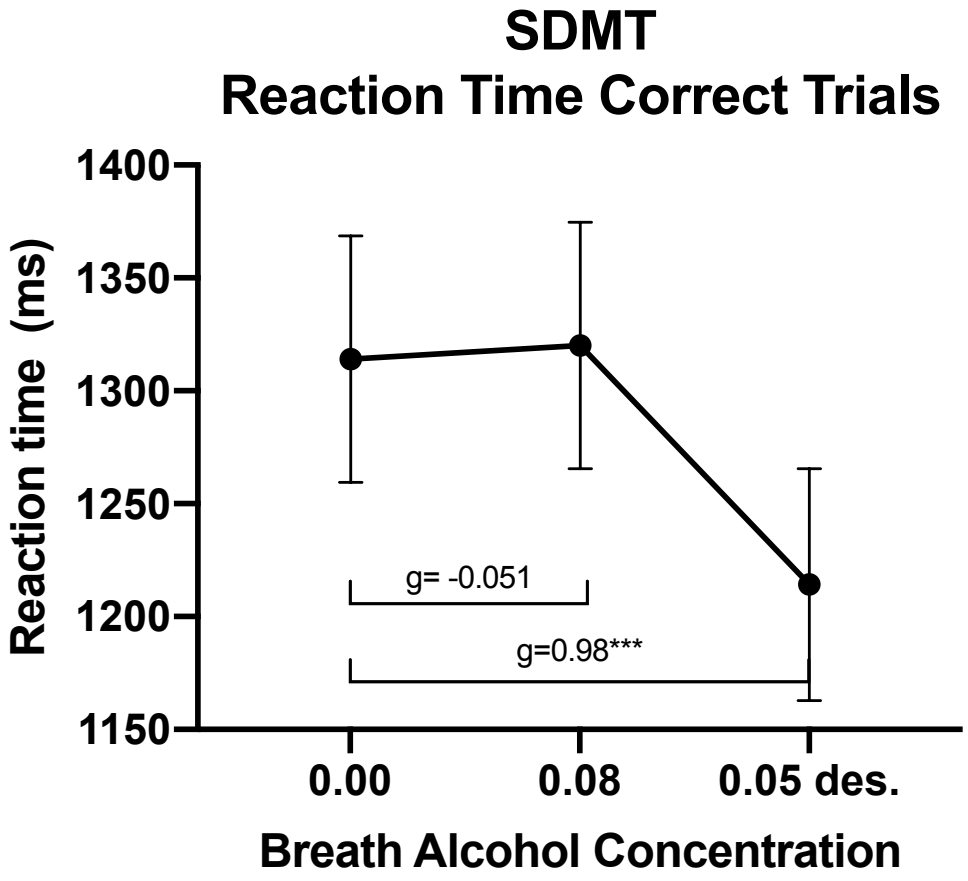


Figure 12. SDMT Reaction Time to Correct trails with 95% confidence intervals and effect sizes at baseline 0.00 and 2 breath alcohol time points.
**=p<.01; ***=p<.001

Figure 13. SDMT percent errors with 95% confidence intervals and effect sizes at baseline 0.00 and 2 breath alcohol time points.
**=p<.01; ***=p<.001

Table 8

Overall Effects of Alcohol on Processing Speed Measures.

Measure	*df*	*df*	*F*	*p*
MOPS				
RTC	3	89.13	6.02	0.001
Number of Errors	3	98.03	6.30	0.001
WAIS SS				
Total	2	38.17	16.19	<.001
SDMT				
RTC	2	37.65	36.44	<.001
% Errors	2	42.95	2.35	.017

Note. Controlled covariates in the model are evaluated at the following values: total WTAR score =41.44, age (years) =22.98

Discussion

Table 9

Summary of MOPS Results Compared to Other Processing Speed Measures.

	Correlations		Test retest reliability	Learning effects	Overall UEQ	Cost	Length
Measure	MOPS	WAIS	*r*	*d*	Score	$	Seconds
MOPS RTC	-	-0.69***	0.80***	0.59***	39.33	0	120
WAIS SS Total	-0.69***	-	0.69***	-0.87***	39.91	$$$$	120
SDMT RTC	0.74***	-0.70***	0.90***	1.39***	-	$$$	90

Note. *** $p<.001$; $$$ = $100's; $$$$ =$1,000's.
Overall UEQ = Overall User Experience Questionnaire Score, combining pragmatic and hedonic scores.

Aim

The first study aimed to examine the construct and concurrent validity of the MOPS task with two other measures of processing speed (WAIS Symbol Search and Symbol Digit Modalities Test) and measure of working memory (N-Back test). It also examined the test-retest reliability of the MOPS task, and compared the results to other measures of processing speed. The second study aimed to examine the sensitivity of the MOPS task to acute alcohol intoxication.

Hypothesis 1

The results of study 1 supported the first hypothesis that the MOPS task would hold strong correlations with other measures of processing speed (WAIS SS and SDMT).

MOPS Reaction Time to Correct trials (RTC) held significant moderate negative correlations with total number of WAIS SS scores in the first session (r=-0.48, $p<.001$),

increasing to strong correlations in the second session (r=0.69, p<.001) (Table 9). This increase may be due to variance between tests that occurred in the first testing session reduced in the second session as participants became more familiar with the tasks; resulting in more accurate estimate of the tasks correlations.

MOPS RTC held significantly strong correlations with SDMT RTC in both session 1 (r=0.708, p<.001) and 2 (r=0.737, p<.001).

Other computerised tests of processing speed show strong correlations with SDMT. Rao et al. (2017) designed a computerised task of processing speed to resemble the SDMT. The strong correlations found between those two tests indicates the transition from pencil-and-paper to digital did not hinder the digital test's ability to measure processing speed. Accordingly, the strong relationship between the two tests is expected as the digital task was based on the same format as the SDMT. The MOPS is not based off the SDMT format, therefore the strong correlation the MOPS holds with the SDMT can infer the MOPS measures processing speed equivalent to other digital SDMT measures. Such alternate forms of the SDMT have shown moderate to strong correlations with the original format (Hinton-Bayer & Geffen, 2005; Slwinski et al., 2018).

The computerised concussion tests IMPACT and CogState hold moderate and strong positive correlations with the SDMT and DSST (Iverson et al., 2005; Makdissi et al., 2002). The Cogstate identification task is comparable to the MOPS in its response features. Respondents using the Cogstate identification task respond YES or NO based on identifying the stimulus according to a 'rule' (have you seen this before? Is it red?) (Maruff et al., 2009). Responses are also measured in reaction time (milliseconds) and accuracy. The recognition aspect in responding, two response format, and reaction measurement are comparable to the MOPS process. Future testing would be to directly compare the MOPS to these computerised

to concussion tasks to identify if the MOPS is a useful tool to come alongside concussion and sport based traumatic-brain-injury measures.

Based on the strong correlations the MOPS hold with other measures of processing speed the construct validity of the MOPS as a digital measure of processing speed is supported. The validity of the maintenance of processing speed measures in the transition from pencil-and-paper to computerised was examined by Mead and Drasgow (1993). A meta-analysis of 36 speeded tasks, similar to the MOPS, had overall strong positive correlations (r=0.72) with pencil-and-paper counterparts. Note that the meta-analysis was conducted in 1993 and technology has increased exponentially in the 25 years since. This raises the question: do tests on current technology correlate well with pencil-and-paper tests, or even with the early computerised versions? Research indicates that the change in technology processing speed tests are delivered on has not hampered the ability to measure processing speed (Rao et al 2017; Tiplady, 2010; Noyes & Garland, 2008; Makdissi et al., 2001; Cameron, Sinclair, & Tiplady, 2001).

The temporal resolution of tablets is lower than those of keyboards, and this is important to consider when comparing reaction times of tasks on each device. The exact degree of resolution and amount of inaccuracy in tablets compared to keyboard computers is unclear. This is an important factor to consider in further development of the MOPS test; as it may play into the reduced sensitivity results of the task. It may make the ability to find small differences between two groups difficult to identify due to the noise. The use of the HOLD button is one method aimed to improve the standardisation of MOPS RT recording resolution. While tablets may be less sensitive experimentally than a keyboard-based test, the results and portability of the tablet are still useful clinically.

Overall, the MOPS task holds strong correlations with other measures of processing speed as hypothesised.

From the short form user experience questionnaire, the MOPS task was also equally liked as the WAIS SS overall and on both pragmatic and hedonic scale scores (Table 9).

Hypothesis 2

MOPS RTC held statistically significant weak correlations with N-Back RTC in the second session (r=0.39, p<.001) supporting the second hypothesis.

The results from the current study are supported by previous research examining the relationship between processing speed and working memory. Sliwnski's et al. (2018) computerised processing speed tests had weak negative correlations with working memory tests (r=0.32). Moderate negative correlations between processing speed and working memory were also found by Fry and Hale (1996), with processing speed impacting working memory. Conway et al. (2002) also found weak negative correlations between processing speed measures and working memory measures. However, standardised measures of processing speed were not examined in the study, and the DSST was excluded from analysis as it did not correlate with any of the other processing speed measures used. Therefore, an indication of how a standardised processing speed measure correlates working memory measures was not assessed in Conway's et al. (2002) study.

Within the current study, the N-Back working memory measure accounted for approximately 12% of the variance in the MOPS task (r=0.39). This finding is supported by past research examining the amount variance working memory accounts for in processing speed measures (Joy et al., 2004). The comparison of Wechsler Memory Scale 3 index measures of working memory alongside the Digit Symbol Coding (WAIS 3) scores, found weak positive correlations. From mean correlations, working memory measured by the WMS accounted for 15% of the variance in the Digit Symbol Coding; a similar variance to the MOPS task. Using less the comparable incidental memory tasks of free recall and paired associates alongside the Digit Symbol Coding, working memory accounted for small but

significant 7% of variance (Joy et al., 2004). The importance of speed, assessed by the Digit Symbol Copy, was highlighted by accounting for 50% of the variance in the Digit Symbol Coding. Yet working memory plays a small but significant secondary process in the measuring of processing speed. The measures used in Joy et al. (2004) study have since been updated to the WAIS IV. While the amount working memory may play in measuring processing speed is unlikely to have increased significantly during the time between updates, differences in measures should be assessed to develop a more updated measure. While working memory is measured in processing speed measures, the small percentage indicates working memory ability is not the key process assessed.

Overall, the MOPS holds moderate magnitude correlations with tasks of working memory it contributes to, as hypothesised.

Hypothesis 3

Moderate magnitude learning effects (d=0.59, p<.001) were identified in the MOPS task between the first and second study, not supporting the third hypothesis. While large magnitude learning effects were found in both the WAIS SS (r=-0.87) and the SDMT (r=1.39) (Table 9).

Past literature identifying learning effects in tests of processing speed tests are similar to the learning effects found in the measures of processing speed in the current study (Falleti et al., 2006; Strauss, Sherman, & Spreen, 2006; Cole et al., 2013)

Methods aiming to reduce learning effects developed into the design of the MOPS were based off identified influences that increase learning effects in the WAIS SS and SDMT. The WAIS SS uses a conventional test format; every user receives the same test format, with the same items, in the same order, for every session. This has resulted in the WAIS SS having high learning effects (Lichtenberger & Kaufman, 2009; Wechsler. 2008). The SDMT uses a semi-conventional format, with the same 9 symbols and 9 numbers in the

key, with combinations only varying between test sessions. This reduces the novelty of stimuli and can increase learning effects. The MOPS aimed to overcome these problems by using an unconventional test format. Stimuli presented in the MOPS are different in every trial and in each test. The combination of 4 outer shapes and 90 potential inner shapes in each trial, alongside randomly changing location of target symbols, allows many variations of the test to be generated. It is highly unlikely that a participant will receive the same MOPS test twice, or the same combination of stimuli within a test. The moderate magnitude learning effects found in the MOPS compared to the large learning effects in the WAIS SS and SDMT indicate these measures put in place reduced learning effects. However, the moderate magnitude learning effects where RTC significantly decreased in the second session were still somewhat unexpected. Whether the differences between the two sessions was due to an increase in task familiarity or cumulative learning effects needs to be further identified (Falletiet al., 2006). Within the second study, a MOPS double baseline was applied before alcohol consumption. Learning effects were still identified across the consecutive sessions. Applying the MOPS over multiple sessions without impairment, allows any plateau in learning effects to be identified after a certain number of sessions, or if it continuously increases beyond initial familiarisation (Falletiet al., 2006).

The good test retest reliability of the MOPS task (r=0.80) found in the first study supports hypothesis 3. The acceptable test retest reliability indicates that participants perform similarly across sessions, for example those who are fast in session 1 will likely be fast in session 2.

The test retest reliability of the MOPS as a mobile tablet measure is supported by past research of computerised processing speed tests (Cole et al., 2013). Smartphone tests of processing speed maintained acceptable test retest reliability (r=0.70) (Brouillette et al., 2013; Cole et al., 2013). The Mindstreams battery of self-administered computerised tests

with 3 processing speed measures, maintained questionable test retest reliability when tested three weeks apart (Schweiger, Doniger, Dwolatzky, Jaffe, & Simon, 2003).

The ability for processing speed tests to maintain high reliability, with low learning effects is essential for testing over multiple sessions. Using long-test retest intervals to avoid learning effects, such as in WAIS IV administration, is not feasible when multiple assessments need to be made, such as concussion monitoring (Hinton-Bayer & Geffen, 2005). The test retest reliability of smartphone processing speed tests over four testing sessions 10 minutes apart was examined by Timmers et al. (2014). The tests maintained acceptable reliability over the four testing sessions (ICC=0.76), indicating participants performed similarly each session. Yet participants scores significantly increased approximately one point a session. This increase is small and of comparable magnitude to the MOPS task. The majority of practice effects in the smartphone tasks were identified between the first and second session of the experiment. The moderate magnitude learning effects identified in the MOPS were also identified between the first and second session.

Overall, the MOPS generated moderate magnitude learning effects, which were smaller than the large magnitude learning effects identified in other measures. The MOPS also held acceptable test retest reliability, like the other measures of processing speed.

Hypothesis 4

The hypothesis the MOPS task would be sensitive to acute alcohol intoxication was supported by results in study 2. However, learning effects interfered with the ability to identify effects at peak 0.08 and 0.05 descending BrAC.

While pairwise comparisons did not identify significant differences in MOPS RTC from 0.00 baseline BrAC to the three alcohol time-points; there was a weak magnitude increase in RTC from 0.00 baseline BrAC to 0.05 ascending BrAC (r= -0.305) (See Figure 9). The WAIS SS task and SDMT only identified trivial non-significant changes from 0.0

baseline BrAC to 0.08 *peak* BrAC (r=-0.064 and r=-0.051 respectively). The MOPS, while not strongly sensitive to acute 0.05 BrAC alcohol, was more sensitive to effects than the other two measures of processing speed which did not identify any effects at 0.08 peak BrAC.

The influence of learning effects identified in study 1 were present when the expected increase in MOPS RTC at 0.08 peak and 0.05 descending BrAC did not occur (Zoethout et al., 2011) (see Table 2). The weak, non-significant decreases in RTC from baseline to these time-points (0.08 peak and 0.05 descending) indicate learning effects had taken place on the fourth and fifth completions of the test (See Figure 9) (A double baseline at 0.00 BrAC was done to in attempt to reduce learning effects between baseline and first intoxication test (0.05 ascending). This overall impacted the sensitivity of the MOPS to identify alcohol intoxication at peak levels.

The WAIS SS indicated high learning effects over the study 2 testing session. This was indicated by no significant decreases in total score at peak alcohol intoxication, but a significant large magnitude increase in total scores made in the last testing session while still under acute intoxication (0.05 descending BrAC) (See Figure 11). The SDMT demonstrated acute tolerance effect as reaction time significantly decreased in the third testing session descending 0.05 BrAC but no change in errors occurred (Fillmore, Marczinski, & Bowman, 2006).

Overall, the MOPS, while not strongly sensitive to acute 0.05 BrAC alcohol, was more sensitive to effects than the other two measures of processing speed which did not identify effects at peak and were impacted by large magnitude learning effects/acute tolerance effect.

Limitations and Future Research Directions

The key limitation of both studies was the moderate magnitude learning effects identified in the MOPS task. This impairs the ability of the MOPS in its current format to be

used in multiple testing sessions without a control. The learning effects also impair the ability to identify if changes in processing speed are due to improvements in functioning or due to learning. Further examination of the learning effects and test-retest correlations between the easy and difficult trials within the MOPS could be used to identify if one condition reduces learning effects over the other.

Future directions of the MOPS include the creation of norms for various samples; in which impairment or improvement in processing speed could be compared and monitored. The creation of automatic scoring feedback integrated with normed data would allow the task to become even more portable and results accessed in a timely manner. The task can be used to track performance for individuals over multiple sessions, comparing results to baseline performance. Post adaptations, being a free measure of processing speed that requires minimal training and easy to understand results, is the key aim for the MOPS test to be successful.

Conclusion

The current study examined how a new mobile processing speed test (MOPS) performed over two testing sessions and under acute alcohol intoxication. The MOPS test is a good mobile measure of processing speed based on the strong correlations it held with other measures of processing speed. The impact of learning effects, while a hindrance, are not as significant as the other processing speed measures. Diligence will need to be taken when running multiple sessions to use a control sample until the learning effects are reduced. The MOPS sensitivity to impairment is also positive compared to the other measures, although learning effects did hinder detection ability at peak. Overall the MOPS test is a viable mobile measure of processing speed. It is portable, cheap, and easy to administer in real world environments.

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Appendices

Appendix A: Study 1 User Experience Questionnaire – Short form. MOPS/ WAIS SS

Thinking about the Symbol Search task that you just completed, would you say that it was....							
	boring						exciting
1	○	○	○	○	○	○	○
							reset
	not interesting						interesting
2	○	○	○	○	○	○	○
							reset
	conventional						inventive
3	○	○	○	○	○	○	○
							reset
	usual						leading edge
4	○	○	○	○	○	○	○
							reset
	obstructive						supportive
5	○	○	○	○	○	○	○
							reset
	complicated						easy
6	○	○	○	○	○	○	○
							reset
	inefficient						efficient
7	○	○	○	○	○	○	○
							reset
	confusing						clear
8	○	○	○	○	○	○	○
							reset

Appendix B: Study 1 Ethics Approval

UNIVERSITY of TASMANIA

20 May 2019

AssocProf Raimondo Bruno
C/- University of Tasmania

Sent via email

Dear AssocProf Bruno

REF NO: H0018073
TITLE: Validation of brief mobile/tablet based assessments of processing speed, inhibitory control and impulsivity

We are pleased to advise that acting on a mandate from the Tasmania Social Sciences HREC, the Chair of the committee considered and approved the above project on 09 May 2019.

Please ensure that all investigators involved with this project have cited the approved versions of the documents listed within this letter and use only these versions in conducting this research project.

This approval constitutes ethical clearance by the Tasmania Social Sciences HREC. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approvals of other bodies or authorities are required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

In accordance with the National Statement on Ethical Conduct in Human Research, it is the responsibility of institutions and researchers to be aware of both general and specific legal requirements, wherever relevant. If researchers are uncertain they should seek legal advice to confirm that their proposed research is in compliant with the relevant laws. University of Tasmania researchers may seek legal advice from Legal Services at the University.

All committees operating under the Human Research Ethics Committee (Tasmania) Network are registered and required to comply with the *National Statement on the Ethical Conduct in Human Research* (NHMRC 2007 updated 2018).

Therefore, the Chief Investigator's responsibility is to ensure that:

(1) All investigators are aware of the terms of approval, and that the research is conducted in compliance with the HREC approved protocol or project description.

(2) Modifications to the protocol do not proceed until **approval** is obtained in writing from the HREC. This includes, but is not limited to, amendments that:

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Appendix C – Study 1 Online screening questionnaire

Pre-Screening Survey

Please complete the survey below.

Thank you!

Researchers at UTAS have developed some new cognitive tasks that can be used on smartphones or tablets. We want to make these freely available for other researchers and for clinical purposes. Before we can unleash them, we need to make sure that the new tasks on mobile phones/tablets work in the same way as pencil and paper-based and other versions of the tasks.
Participation will involve 2 x 45-30 minute sessions, run at the University of Tasmania Sandy Bay Campus. Sessions are conducted approximately 1 week apart.
You will be reimbursed $20 at the end of the second session.
Thank you for your interest.

Please complete the information below.

What is your age group?
20-29
30-39
40-49
50-59
60-64
other
reset

What is your gender?

Do you have any problems with your eyesight that aren't corrected by glasses or contacts?
Yes
No
reset

Do you have any concerns about your memory or attention span?
Yes
No
reset

Do you have any major health issues currently?
Yes
No
reset

Are you taking any prescribed medications currently (not including contraception)
Yes
No
reset

Do you have any current mental health problems?
Yes
No
reset

What is your main language?
English
Other
reset

Have you previously completed the Transdermal Alcohol and Cognition Study?
Yes
No
Unsure

Thank you answering the screening questionnaire, we appreciate your assistance. The researchers will be in contact with you as quickly as possible to confirm whether you are eligible to participate

What is your email address?

What is the best phone number to contact you on?

Please indicate which days would suit you best for completing these sessions
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday

Submit

Save & Return Later

Appendix D- Study 1 Information Sheet

Validation of brief mobile/tablet based assessments of processing speed, inhibitory control and impulsivity

Invitation

This is an independent study conducted by Associate Professor Raimondo Bruno, in the School of Medicine (Psychology) at the University of Tasmania. Other researchers involved in the study include Dr Matthew Gretton, who programmed one of the tasks, and Tanya Wilson, Erin Van Der Kley and Megan Young as part of their research for the degree of Honours in psychology.

What is the purpose of this study?

We have developed **three** new tests that can be used on mobile smartphones or tablets. They will look at processing speed, inhibitory control, and impulsivity. We want to make these freely available for other researchers and for clinical purposes. Before we can put these new tests out to be used, we need to make sure that the new tests on mobile phones/tablets work in the same way as pencil and paper-based and other versions of the tasks. We also need to make sure that they give a reliable measure of people's processing speed, inhibitory control and impulsivity – and by that we mean that it should give you similar results if you repeat the test. Once we have tested these, then we will be able to confidently use the new test in research studies and make them available for others to use.

Processing speed is basically a measure of how quickly your brain can deal with information and make decisions. For example, working out if something on a computer screen is an X or a Y; or seeing if there is a match among a group of images. Processing speed is an important part of cognition (thinking) because it is a skill that is necessary for performing well in a number of different areas. For example, how well you can work with information in working memory (such as doing maths problems in your head) depends on how quickly you can process information. This new test is based on a very well used task that is usually done with pencil and paper. We have made a new and harder version that works on mobile phones so that we can measure processing speed in real world contexts. In the future, we're hoping to use this task to do things like measure processing speed over the work day in people who work with complicated machinery; to measure processing speed over the course of an evening out while people are drinking alcohol; or over the course of attending music festivals.

Inhibitory control is how good you are at stopping responses once you've started. For example, like when you have started to move into a different lane while driving but suddenly notice a car in your blind spot, so you shift back into your original lane. The ability to do this skill is really important for a number of areas, but in particular things like being able to withstand cravings and staying abstinent when you're trying to stop smoking or drinking. The existing measures for this are good but both expensive and pretty boring for people to complete. We have developed a new measure that we hope is more interesting, based on the traditional 'whack-a-mole' game.

Impulsivity is about whether your decisions are focused on immediate reward or what is better for you in the long term. Like, for example, when you are hungry and need to choose between satisfying but unhealthy foods (like hot chips) and less satisfying but more health foods (like fruit). We have made a short version of a questionnaire that asks about preferences for immediate vs long term rewards.

Why have I been invited to participate?

We're inviting any adults between 20 and 64 who are healthy and not taking any medications that are willing to help us validate these tasks.

We're not just asking people who are university students to take part, but if you are involved with the University of Tasmania, you should know that if you don't want to take part in this study, that is OK, and it is not going to have any impact on the way you are treated by the University. If you start taking part in this study, and decide that you don't want to continue, that's not going to have any impact on how the University will treat you either.

What will I be asked to do?

There's two parts to this study. Each part will take between 30 and 45 minutes.

After making sure that you are eligible to take part, you will be given some tests of cognition (thinking). These might ask you to pronounce some unusual words out loud (like 'yacht'), to pick the direction of an arrow on screen as quickly as possible, to work out whether there are matches in a group of images. Each of these are pretty short (2-4 minutes) and are designed to be tricky.

Then you will complete the three new tasks:

Processing speed: What you will need to do is to work out, as quickly as possible, if any of a group six images on screen are an exact match to either of two target images. There will be a lot of these trials, and about half of them will be matches and half of them won't match.

Inhibitory control: This is just like a game of 'whack-a-mole'. Here, different sorts of bottles will pop up on a screen, one at a time. As quickly as possible you have to smash any bottles of healthy drinks (like water or oange juice). Every now and then, a bottle of alcohol (beer or wine) will pop up, and you have to avoid hitting those ones. You will have around 100 trials to get as many points (for hitting the right targets) as possible.

Impulsivity: Here you just need to answer a bunch of 'would you rather'-type questions. For example, you might be asked "Would you prefer $54 today or $55 in 117 days?". All you have to do is pick whether you would, hypothetically, prefer to have the money today or to wait for the larger option. There are no 'right' or 'wrong' answers, we're just interested in your opinion.

You can take regular breaks (we'll remind you about this option).

About a week later, we'd like you to invite you to come back and do the same tasks again. This might seem a little pointless, but knowing how much people's performance changes after they have done the task is critically important if we are going to use the test in repeated studies.

It is important to know that it's up to you whether you want to do any of these bits of the study, and if you are only ok with some parts and not others, that's ok, you can still take part in the bits of the study that you are comfortable with.

Are there any possible benefits from participation in this study?

The main benefit from taking part in this study is making a contribution to science by making sure that the tests we use are valid.

We appreciate your time and inconvenience in contributing to research, and we are able to provide reimbursement of $10 for each of the sessions ($20 in total, paid once you've completed both parts). If you decide to do only one part, we will of course provide the amount of payment for the part you complete.

Are there any possible risks from participation in this study?

These tests are all designed to be challenging, but it is unlikely that you would find them stressful or that they would cause you to be upset. It might feel a bit annoying if you make a mistake but the tests are all designed to be challenging enough so that ***everybody*** is going to make mistakes somewhere.

We are going to keep your personal details confidential. The consent forms with identifying information (such as your contact details) are kept separately from all other information from this study (such as the questions about your substance use). They are stored securely at the University. All information from the study is stored only with a study ID (e.g. CTX777). As

soon as you complete the study, any link between your identifying information and study ID is securely destroyed, making it very difficult for an individual person to be identified by their data.

What if I change my mind during or after the study?

As noted above, it is completely fine for you to decide not to answer any questions that you're not comfortable with. That won't affect your relationship with the University. The same applies if you start the study and then decide that it is not for you. You don't need to explain why. If you decide to withdraw, you will still receive reimbursement for your time involved in the study, on a pro-rata basis.

If you decide that you don't want to be part of the study, and you let us know before the end of your participation in the study, we'll be able to work out which data is yours and we can delete all records and securely destroy any consent forms. If you let us know after you have finished all the parts of the study, we won't be able to remove your data because we would have destroyed the links between your identifying information and the study ID.

What will happen to the information when this study is over?

Identifying information will be destroyed as soon as any individual participant completes their part of the study. All the information about performance on the different tasks are stored only using study ID. This will be stored in an electronic database, on secured University of Tasmania servers, and password protected. Hard copies (of your consent form with no link to a study ID) are stored in locked filing cabinets in University of Tasmania storage archives. Both electronic and hard copy data will be destroyed five years after the first publication from this study.

A reminder: any information obtained for the purpose of this study that can identify you will be destroyed as soon as you have completed your part in the study or withdrawn your consent. All information, regardless of whether it is identifying or not, will be treated as confidential and always securely stored.

The data from the tests doesn't provide any useful diagnostic information – it is mainly just information about reaction times. Where it is used in research is to test for *changes* as people get tired, or consume alcohol, or are prescribed medications and the like. Because of this, we are not planning on providing any feedback about your performance to you.

How will the results of the study be published?

Study findings will be presented in formal publications and in conference presentations. Only group level analyses will be reported, so there is no way that a particular individual could be identified in any publication. The results will be available on the university of Tasmania publications repository, WARP (https://rmdb.research.utas.edu.au/public/rmdb/q/warp_home) or specifically here: https://rmdb.research.utas.edu.au/public/rmdb/q/indiv_detail_warp_trans/3812#research-tab-5. You can also contact Raimondo Bruno directly here: Raimondo.Bruno@utas.edu.au

What if I have questions about this study?

If you have questions about the study, you can contact Raimondo Bruno at 03 6226 2240 or Raimondo.Bruno@utas.edu.au.

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on +61 3 6226 6254 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number H0018073**.**

Thank you for your interest in the study, and your time in reading this information sheet. This is for you to keep. If you want to take part in this study, there is a consent form for you to complete. This will be stored separately from the test results.

Appendix E – Study 1 Consent form

Validation of brief mobile/tablet based assessments of processing speed, inhibitory control, and impulsivity

Consent form for participants

1. I agree to take part in the research study named above.
2. I have read and understood the Information Sheet for this study.
3. The nature and possible effects of the study have been explained to me.
4. I understand that the study involves completion of a number of brief tests, on computers, and pencil and paper, of my thinking.
5. I also understand that I will be asked to come to a second session to repeat these tasks, in order to measure how test performance holds up over time.
6. I understand that participation involves no foreseeable risks.
7. I understand that all my data will be labelled only with a study ID, not my name or any other identifying information, and that any link between my name and Study ID will be destroyed as soon as I have completed my role in the study, whether that be by completion of both sessions or decide to discontinue for any other reason.
8. I understand that all research data will be securely stored by study ID only on the University of Tasmania premises for five years from the publication of the study results, and will then be securely destroyed.
9. Any questions that I have asked have been answered to my satisfaction.
10. I understand that the researcher(s) will maintain confidentiality and that any information I supply to the researcher(s) will be used only for the purposes of the research.
11. I understand that the results of the study will be published so that I cannot be identified as a participant.
12. I understand that my participation is voluntary and that I may withdraw at any time without any effect.

    I understand that I will not be able to withdraw my data after completing all parts of the study, as any links with identifying information will have been destroyed. Before this point, I am able to withdraw my data if I so wish.

Participant's name: _____

Participant's signature: _____

Date: _____

Statement by Investigator

☐ I have explained the project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have had the opportunity to contact me prior to consenting to participate in this project.

Investigator's name: _____

Investigator's signature: _____

Date: _____

Appendix F- Study 2 Ethics Amendment Approval

Dear AssocProf Bruno,

Ethics Ref: H0016125
Title: Longitudinal Study on Alcohol, Harm and Cognitive Performance in the Festival Environment

This email is to confirm that the following amendment was approved by the Executive Officer on behalf of the Tasmania Health and Medical Human Research Ethics Committee on 6/5/2019:

Amendment Additional Staff: Erin Van Der Kley, Megan Young, Tanya Wilson
Information Sheet PITP Information Sheet - Apr2019

All committees operating under the Human Research Ethics Committee (Tasmania) Network are registered and required to comply with the National Statement on Ethical Conduct in Human Research (NHMRC 2007).

This email constitutes official approval. If your circumstances require a formal letter of amendment approval, please let us know.

Should you have any queries please do not hesitate to contact me.

Kind regards

Gina Zappia
--
Ethics Officer
Office of Research Services
University of Tasmania
Private Bag 01
Hobart TAS 7001

Email: Human.Ethics@utas.edu.au
http://www.utas.edu.au/research-admin/research-integrity-and-ethics-unit-rieu

Appendix G – Study 2 Online Screening Questionnaire

UTAS Transdermal Alcohol and Cognition Study

Thank you for your interest in participating in this research. The purpose of this study is to investigate the relationship between transdermal alcohol concentration, breath alcohol concentration and cognitive performance. Participation will involve attending one 240 minute experimental session at the Psychology Research Centre, Hobart campus, University of Tasmania.

In this session participants will consume a maximum of six standard alcoholic drinks. Participants will then complete computerised behavioural laboratory tasks. Breath alcohol concentration (BrAC) and transdermal alcohol concentration (TAC) will be monitored using hand held breathalysers and transdermal leg bracelets, respectively. Both of these devices are safe and considered non-invasive. At the end of the experimental session, participants will remain at leisure at the Psychology Research Centre until two consecutive BrAC measurements of 0.03% or less are recorded. Participants will be reimbursed $50 for participation.

We are currently seeking healthy participants who: are aged 18-35, have English as a first language, have completed Year 12, have normal or corrected-to-normal vision, have normal sleep patterns, have no history of any significant neurological condition (including epilepsy), have no significant current physical condition, have no current diagnosis of a significant psychological condition or intellectual disability, regularly consume alcohol, are not regularly taking prescription medication, are not currently using illicit drugs and are able to attend the Hobart campus of the University of Tasmania for one 240 minute session.

If you are still interested and eligible to participate in this research, please complete the following online screening questionnaire. Please note that all information will be kept confidential and securely stored. You can close this browser window at any point during the questionnaire if you are no longer interested in participating. Once again, thank you for your interest in our research. We appreciate your assistance.

What is your age in years?

What is your sex?

What is your e-mail address? This is so we can contact you.

What is the phone number you are most easily reached on?

What was the highest grade of school you completed?

Which state do you currently live in?

Is English your first language?

- Yes
- No

reset

Which type of drivers license do you currently hold?

Health

Do you have any difficulties with vision?	○ Yes ○ No reset
Do you have a sleep disorder or any sleeping difficulties?	○ Yes ○ No reset
On average, how many hours do you sleep on a weekend?	
On average, how many hours do you sleep on a weeknight?	
Do you work night shifts (e.g., 10pm - 6am) or double shifts (e.g., 8am until midnight)?	○ Yes ○ No reset
Have you ever had or are you now suffering from any of the following?	☐ Fits or convulsions ☐ Epilepsy ☐ Regular giddiness ☐ Concussion ☐ Severe head injury ☐ Loss of consciousness ☐ Diabetes ☐ Hypetension ☐ Gastro-oesophageal reflux condition ☐ Heart condition ☐ Substance abuse/dependence disorder
18. Do you have any other serious physical conditions?	○ Yes ○ No reset
Are you currently suffering from anxiety or depression?	○ Yes ○ No reset
Do you have any other serious mental health conditions?	○ Yes ○ No reset
What is your approximate height in cm?	Note that 1ft = 30.5cm. Please write "I don't know" if you're not sure.
What is your approximate weight in kg?	Note that 1kg = 2.2 pounds. Please write "I don't know" if you're not sure.

Alcohol Use

Have you consumed an alcoholic drink in the last fortnight (14 days)?	○ Yes ○ No reset
How many standard alcoholic drinks have you consumed in the last fortnight?	

The following questions ask about your alcohol use in the last 12 months. Please note that all alcohol quantities are provided in standard drinks. All information provided will be kept confidential.

How often do you have a drink containing alcohol?	
How many standard drinks containing alcohol do you have on a typical day when you are drinking?	
How often do you have six or more standard drinks on one occasion?	
How often during the last year have you found that you were not able to stop drinking once you had started?	
How often in the last year have you failed to do what was normally expected of you because of drinking?	
How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?	
How often during the last year have you had a feeling of guilt or remorse after drinking?	
How often during the last year have you been unable to remember what happened the night before because of your drinking?	
Have you or someone else ever been injured because of your drinking?	
Has a relative or friend or a doctor or other health worker ever been concerned about your drinking or suggested you cut down?	

Other Drug Use

How often do you smoke tobacco?	
Have you used cannabis in the last month?	○ Yes ○ No reset
Have you used any form of illicit drugs in the past month?	○ Yes ○ No reset
Are you currently regularly taking prescription medication for medicinal or recreational purposes?	○ Yes ○ No reset

Statement of Study Restrictions

Have you participated in another study within the last three months for which you had to consume any drugs?

- Yes
- No

reset

Thank you for answering the previous questions. There are now just a few questions to ensure you are aware of what participation involves to ensure that you will be able to complete the study.

Will you be able to attend one 240 minute experimental session at the University of Tasmania? You will be reimbursed $50 for your participation.

- Yes
- No

reset

Are you willing to drink up to six standard alcoholic drinks during the experimental session? Please note that you will not be informed of the specifc quantity of alcohol administered in the beverage until conclusion of the session.

- Yes
- No

reset

Prior to the session, participants will be asked to abstain from:

- Food for 4 hours
- Caffeine for 8 hours
- Alcohol for 24 hours
- Prescription medication for 24 hours
- Illicit drugs during the course of participation

Can you agree to abstain from these items for the specified time?

- Yes
- No

reset

Are you willing to remain in the laboratory until you breath alcohol concentration is recorded at .03% or less? Provisional license holders who are intending to drive will have to remain in the laboratory until their breath alcohol concentration is at .00%. If not intending to drive provisional license holders will have to remain in the laboratory until their breath alcohol concentration reaches .03% and be required to organise alternative transportation after the session. In addition to food and drink, DVDs and magazines will be provided in the interim.

- Yes
- No

reset

Thank you answering the screening questionnaire, we appreciate your assistance. The researchers will be in contact with you as quickly as possible to confirm whether you are eligible to participate. Please email Thomas Norman at utastransdermalstudy@gmail.com if you have any queries or would like a copy of the information sheet.

Please indicate which days would best suit you for completing the experimental session:

- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday
- Sunday

Submit

Appendix H- Study 2 Information Sheet

School of Medicine University of Tasmania

Information Sheet

Alcohol Intoxication, Transdermal Alcohol Assessments and Cognitive Performance

Version 3, March 2019

Introduction

You are invited to participate in a study examining the relationship between transdermal alcohol assessments, cognitive performance and alcohol intoxication. This research is being conducted by Thomas Norman, as partial fulfilment of a Doctor of Psychology degree. Thomas is being supervised by Associate Professor Raimondo Bruno and Dr Amy Peacock from the School of Medicine (Psychology), University of Tasmania. The researchers can be contacted as following: Thomas Norman (Thomas.Norman@utas.edu.au) or Raimondo Bruno (Raimondo.Bruno@utas.edu.au).

What is the purpose of the study?

The purpose of this study is to investigate the degree to which transdermal alcohol concentration relates to alcohol intoxication and cognitive performance (e.g., reaction time, accuracy, decision-making,) outcomes.

Who can participate?

We are currently seeking participants who are:

- Male or female
- Aged 18 years or over
- Completed Year 12
- Normal or corrected-to-normal vision
- Normal sleep patterns
- Healthy (no history of significant neurological disorder or current psychiatric disorder, significant intellectual disorder, alcohol/drug dependence, regular tobacco use, or chronic health problems)

- Regular alcohol consumers (minimum consumption of 2 standard alcoholic drinks on one occasion in the preceding month).
- Not currently using illicit drugs (i.e., usein the preceding 6 months).

Able to attend the Hobart campus of the University of Tasmania for one three hour session conducted between 9am and 7pm.

What does participation in the study involve?
This research will be conducted in the Perception Laboratory at the School of Psychology, University of Tasmania (Hobart). Interested individuals will complete a brief screening questionnaire that collects data about demographics (e.g., age, sex), medical history, pregnancy/breastfeeding status (females only), psychological wellbeing, reading ability, use of alcohol and other drugs. Eligible participants will be asked to attend one three hour session at the psychopharmacology laboratory.

If participants are deemed eligible, they will be invited to participate in a laboratory session. During this session, participants will be dosed with alcohol (up to .05 breath alcohol concentration) and asked to complete a series of cognitive tasks on a tablet. A breathalyser will be used to monitor participants' breath alcohol concentration throughout the duration of the study. They will be fitted with a continuous alcohol monitoring bracelet around their ankle, which will be worn during the course of the session and taken off before they leave. This bracelet can be taken off at any time if the participant wishes to do so. Session length is dependent on the time taken for the participant to record two consecutive breath alcohol readings of .03% or less (.00% for Provisional licence holders intending to drive). Depending on the individual's rate of alcohol absorption and elimination this time may vary and therefore some sessions may take longer than three hours to complete.

What are the restrictions regarding participating?
Participants will be asked to abstain from alcohol and over-the-counter medication for 24 hours prior to the laboratory session. Participants will be asked to abstain from illicit drugs and tobacco for the duration of participation.

At the end of the laboratory session, participants will remain at leisure (with food and entertainment provided) until they attain two consecutive breathalyser recordings of 0.03% or less measured 15 minutes apart.

Participants holding their provisional driver licence, who are intending to drive will be required to remain in the laboratory until two consecutive BrAC measurements are recorded at .00%. Participants holding their provisional licence who are not intending to drive, will be able to leave the laboratory at .03% BrAC if they sign a declaration in which they agree to be escorted by a nominated guardian to their place of residence and accompanied for a two hour period following session completion. The nominated guardian must be an adult aged 18 years or older who: (i) holds their provisional or full driver licence (ii) directly collects the participant from the research premises and meets the researcher in-person, and (iii) signs a declaration agreeing to escort the participant directly to their place of residence and accompany the participant for the two hour period following session completion. The researcher reserves the right to retain participants in the laboratory until .03% BrAC for those holding their full driver licence and .00% BrAC for those holding their provisional licence when it is deemed unsafe for the participant to leave at .03% BrAC.

What are the benefits of participating?
Your participation will help us enhance our knowledge of the effects of alcohol on transdermal readings and on cognitive performance outcomes. This knowledge can be used to help educate people and the scientific community regarding the potential outcomes and utility of these measures in alcohol-related research.

What are the risks associated with participating?
There are no anticipated risks of this research. However, if in the unlikely event you experience negative side-effects, please inform the experimenter and the necessary assistance will be sought and provided. We ask that participants refrain from consuming alcohol or operating heavy machinery for four hours post-laboratory session.

Is there any monetary reimbursement for participation?
Participants will be reimbursed $50 for participation in the session.

How do I volunteer to participate? What if I want to withdraw from participating?
Participation in this study is voluntary. By signing the attached consent form, you are indicating that you are aware of the nature of the study and wish to participate. While we would be pleased to have you participate, we respect your right to decline. There will be no consequences to you if you decide not to participate. If you decide to discontinue participation at any time, you may do so without providing an explanation. However you will be required to remain in the laboratory until your breath alcohol concentration measurement equals 0.03% or less on two separate occasions measured 15 minutes apart.

What will happen to the information I provide?
All information collected will be kept confidential. Each participant will be assigned a code and individual participant data will be identifiable only by that code. All of the data will be stored on password protected secure computers or in a locked cabinet in the School of Psychology for a minimum of five years after the publication of any academic journal articles, at which point all questionnaires will be destroyed using a paper shredder and electronic data will be deleted. The screening questionnaire will be securely destroyed immediately on completion of the study and that any information provided by the participant on the questionnaire will be identifiable only by participant number, kept confidential, and viewed only by the experimenter.

Who do I contact if I have any queries?
If you would like to discuss any aspect of this study please contact Thomas Norman (Thomas.Norman@utas.edu.au). Alternatively, you can contact Dr Raimondo Bruno on (03) 6226 2240 or email Raimondo.Bruno@utas.edu.au.

How do I find out the results of the study?
A summary of the results will be available on the Research webpage of the School of Psychology, University of Tasmania (http://fcms.its.utas.edu.au/scieng/psychol/). Results of the study can also be provided by Thomas Norman (Thomas.Norman@utas.edu.au).

Who do I contact if I have a complaint about the study?
This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study should

contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote H0016125.

Who do I contact if I wish to speak to someone about my alcohol or drug use, or mental health?

As aforementioned, a number of simple screening questionnaires will be administered assessing psychological functioning and alcohol and other drug use. Whilst it is not anticipated that these questionnaires will cause distress, please do not hesitate to let the researcher know if you do not wish to fill them in. If you are concerned about your drinking or mental health, please contact the Tasmanian Alcohol Drug Information Service 1800 811 994 or Lifeline 13 11 14 (both services available 24 hours a day).

Thank you for taking the time to consider this study.
If you wish to take part in it, please sign the attached consent form.
This information sheet is for you to keep.

Appendix I – Study 2 Consent Form

School of
Psychology
University of
Tasmania

Consent
Form

Alcohol Intoxication, Transdermal Alcohol Assessments and Cognitive Performance

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1. I have read and understood the 'Information Sheet' for this project.
2. The nature and possible effects of the study have been explained to me.
3. I understand that the study involves attending the Cognitive Neuroscience Laboratory for one three hour session. This can be completed on a mutually convenient day of your choosing.
4. I understand that my height, weight, reading ability, psychological wellbeing, demographic information, drug and alcohol use history and pregnancy/breastfeeding status (females only) will be assessed to ensure my eligibility for participation. I understand that in the session I will complete measures of cognitive performance and alcohol use, as well as having my height and weight measured.
5. I understand that I will be asked to sign a declaration and complete a breath alcohol concentration measurement (via a breathalyser) to confirm my abstinence at the start of the laboratory session.
6. I understand that in the laboratory session I will receive a beverage containing alcohol. I understand that I will be given enough alcohol to receive a breath alcohol reading of .05. I understand that after beverage consumption, I will be asked to complete a number of laboratory cognitive-behavioural performance tasks during which my behavioural responses will be recorded. I understand that my breath alcohol concentration will be recorded throughout the laboratory session.
7. I understand that I will be asked to remain in the laboratory until my blood alcohol concentration equals 0.03% or less on two occasions measured 15 minutes apart. I acknowledge that I have been advised to refrain from drinking alcohol or operating a vehicle or other heavy machinery for four hours after the end of the experimental session.
8. I understand that if I hold a provisional driver licence and I intend to drive I will be required to remain in the laboratory until my breath alcohol concentration is .00% on two consecutive occasions. I understand that if I hold a provisional driver licence and do not intend to drive I will be able to leave the laboratory at .030% BrAC after signing a declaration in which I agree to be escorted by my nominated legal adult to my place of residence and be accompanied for a two hour period following session completion. I understand that the nominated legal guardian must be an adult aged 21 years or older who:

(i) holds their provisional or full driver licence (ii) directly collects me from the research premises and meets the researcher in-person, and (iii) signs a declaration agreeing to escort me directly to my place of residence and accompany me for the two hour period following session completion. Furthermore, I understand that the researcher reserves the right to retain participants in the laboratory until .03% BrAC for those holding their full driver licence and
.00% BrAC for those holding their provisional licence when it is deemed unsafe for the participant to leave at .03% BrAC. I acknowledge that I have been advised to refrain from drinking alcohol or operating a vehicle or other heavy machinery for four hours after the end of experimental sessions.

9. I understand that I will be fitted with a continuous alcohol monitoring bracelet during the sessions, but that I may take this off at any time and for any reason.
10. I understand that I will be provided reimbursement to the sum of $50 for participation. If I withdraw from the study prior to concluding all sessions I will not be eligible for monetary reimbursement, unless the withdrawal is due to an unexpected adverse event.
11. I understand that, while there are no anticipated risks associated with this study, I should inform the experimenter immediately if any unexpected negative side-effects are experienced. I understand the experimenter will immediately cease the session and seek the necessary assistance. I understand that I can contact the researchers, Lifeline or the Tasmanian Drug Information Service should I experience any adverse (phone numbers have been provided on the information sheet).
12. I understand that the researchers will maintain my confidentiality and that any information I supply to the researcher(s) will be used only for the purposes of the research. My data will only be identifiable by an individual numerical participant code.
13. I understand that the screening questionnaire will be securely destroyed immediately on completion of the study and that any information I provide will be identifiable only by my participant number, kept confidential, and viewed only by the experimenter.
14. I understand that all research data will be securely stored on the University of Tasmania premises for at least five years, and will then be securely destroyed when no longer required.
15. I agree that research data gathered from me for the study may be published provided that I cannot be identified as a participant.
16. I agree to participate in this investigation and understand that I may withdraw at any time without any effect, and if I so wish, may request that any data I have supplied to date be withdrawn from the research.
17. Any questions that I have asked have been answered to my satisfaction.

Name of Participant _____
Signature of Participant _____
Date _____

Statement by Investigator

I have explained the project & the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked. ☐

The participant has received the Information Sheet where my details have been provided so participants have the opportunity to contact me prior to consenting to participate in this project. ☐

Name of Investigator _____
Signature of Investigator _____
Date _____

Appendix J: ***Overall Effects of Alcohol on Processing Speed Measures without Covariates***

Table
Overall effects of Alcohol on Processing Speed Measures without covariates

	df	*df*	*F*	*P*
MOPS				
RTC	3	89.2	5.98	<.001
Errors	3	99.2	6.01	<.001
WAIS SS				
Total	2	37.64	16.69	<.001
SDMT				
RTC	2	36.25	26.20	<.001
Percent errors	2	43.21	2.37	.105

Note: No covariates were added in to the models